

SERVICE MANUAL

FH Series Forklift Truck

Serial No. 138001~

FH40-1

FH45-1

FH50-1

FH



WARNING

Read and observe all warnings on this unit before operating it.

DO NOT operate this equipment unless all factory-installed guards and shields are properly secured in place.



KOMATSU®

REVISED: SEPTEMBER 2013

Safety notice

(Rev. 2008/07)

Important safety notice

Proper service and repair are extremely important for safe lift truck operation. The service and repair techniques recommended by KOMATSU UTILITY and described in this manual are both effective and safe. Some of these techniques require the use of tools specially designed by KOMATSU UTILITY for the specific purpose.

To prevent injury to workers, the symbol  is used to mark safety precautions in this manual. The cautions accompanying these symbols should always be followed carefully. If any dangerous situation arises or may possibly arise, first consider safety, and take the necessary actions to deal with the situation.

1. General precautions

 **Mistakes in operation are extremely dangerous. Read the Operation and Maintenance Manual carefully before operating the lift truck. In addition, read this manual carefully before starting work.**

- 1) Before carrying out any greasing or repairs, read all the safety labels stuck to the lift truck. For the locations of the safety labels and detailed explanation of precautions, see the Operation and Maintenance Manual.
- 2) Decide a place in the repair workshop to keep tools and removed parts. Always keep the tools and parts in their correct places. Always keep the work area clean and make sure that there is no dirt, water, or oil on the floor. Smoke only in the areas provided for smoking. Never smoke while working.
- 3) When carrying out any operation, always wear safety shoes and helmet. Do not wear loose work clothes, or clothes with buttons missing.
 - Always wear safety glasses when hitting parts with a hammer.
 - Always wear safety glasses when grinding parts with a grinder, etc.
- 4) When carrying out any operation with 2 or more workers, always agree on the operating procedure before starting. Always inform your fellow workers before starting any step of the operation. Before starting work, hang UNDER REPAIR warning signs in the operator's compartment.
- 5) Only qualified workers must carry out work and operation which require license or qualification.
- 6) Keep all tools in good condition. Learn the correct way to use them, and use the proper ones of them. Before starting work, thoroughly check the tools, lift truck, service car, etc.
- 7) If welding repairs are needed, always have a trained and experienced welder carry out the work. When carrying out welding work,

always wear welding gloves, apron, shielding goggles, cap and other clothes suited for welding work.

- 8) Before starting work, warm up your body thoroughly to start work under good condition.
- 9) Avoid working continuously for long hours and take rests at proper intervals to keep the good condition. Take rests in a fixed safe place.

Safety points

1	Good arrangement
2	Correct work clothes
3	Following work standard
4	Making and checking signs
5	Prohibition of operation and handling by unlicensed workers
6	Safety check before starting work
7	Wearing protective goggles (for cleaning or grinding work)
8	Wearing shielding goggles and protectors (for welding work)
9	Good physical condition and preparation
10	Precautions against work which you are not used to or you are used to too much

2. Preparation for work

- 1) Before adding oil or making any repairs, park the lift truck on hard and level ground, and apply the parking brake and block the wheels or tracks to prevent the lift truck from moving.
- 2) Before starting work, lower the work equipment (mast) to the ground. If this is not possible, insert the lock pin or use blocks to prevent the work equipment from falling and hang warning signs on them.
- 3) When disassembling or assembling, support the lift truck with blocks, jacks, or stands before starting work.
- 4) Remove all mud and oil from the steps or other places used to get on and off the lift truck. Always use the handrails and steps when getting on or off the lift truck. Never jump on or off the lift truck.

3. Precautions during work

- 1) Before disconnecting or removing components of the oil, water, or air circuits, first release the pressure completely from the circuit. When removing the oil filler cap, a drain plug, or an oil pressure pickup plug, loosen it slowly to prevent the oil from spurting out.
- 2) The coolant and oil in the circuits are hot when the engine is stopped, so be careful not to get scalded. Wait for the oil and coolant to cool before carrying out any work on the oil or water circuits.
- 3) Before starting work, stop the engine. When working on or around a rotating part, in particular, stop the engine. When checking the machine without stopping the engine (measuring oil pressure, revolving speed, temperature, etc.), take extreme care not to get rolled or caught in rotating parts or moving parts.
- 4) Before starting work, remove the leads from the battery. Always remove the lead from the negative (-) terminal first.
- 5) When raising a heavy component (heavier than 25 kg), use a hoist or crane. Before starting work, check that the slings (wire ropes, chains, and hooks) are free from damage. Always use slings which have ample capacity and install them to proper places. Operate the hoist or crane slowly to prevent the component from hitting any other part. Do not work with any part still raised by the hoist or crane.
- 6) When removing a cover which is under internal pressure or under pressure from a spring, always leave 2 bolts in diagonal positions. Loosen those bolts gradually and alternately to release the pressure, and then remove the cover.
- 7) When removing components, be careful not to break or damage the electrical wiring. Damaged wiring may cause electrical fires.
- 8) When removing piping, stop the fuel or oil from spilling out. If any fuel or oil drips onto the floor, wipe it up immediately. Fuel or oil on the floor can cause you to slip and can even start fires.
- 9) As a general rule, do not use gasoline to wash parts. Do not use it to clean electrical parts, in particular.
- 10) Be sure to assemble all parts again in their original places. Replace any damaged parts and parts which must not be reused with new parts. When installing hoses and wires, be sure that they will not be damaged by contact with other parts when the lift truck is operated.
- 11) When installing high pressure hoses, make sure that they are not twisted. Damaged tubes are dangerous, so be extremely careful when installing tubes for high pressure circuits. In addition, check that connecting parts are correctly installed.
- 12) When assembling or installing parts, always tighten them to the specified torques. When installing protective parts such as guards, or parts which vibrate violently or rotate at high speed, be particularly careful to check that they are installed correctly.
- 13) When aligning 2 holes, never insert your fingers or hand. Be careful not to get your fingers caught in a hole.
- 14) When measuring hydraulic pressure, check that the measuring tools are correctly assembled.
- 15) If the engine is operated for a long time in a place which is not ventilated well, you may suffer from gas poisoning. Accordingly, open the windows and doors to ventilate well.

4. Safety items on maintenance (for safe work)

⚠ Inspection and maintenance shall be carried out by persons having maintenance skill and experience.

- 1) Inspection and repair work of the lift trucks shall be carried out by persons having sufficient knowledge and experience in maintenance and repair work.
- 2) When inspecting or servicing a new model or a new component, fully understand its structure, performance and mechanism.

⚠ Precautions for inspection and maintenance work (preparation)

- 1) Perform inspection and maintenance on a flat, dry, and dustless place.
- 2) When working in a warehouse, ventilate well.
- 3) Keep the inside of the maintenance shop arranged well and work safely.
- 4) Prepare a fire extinguisher against a fire and learn how to use it.
- 5) Before starting inspection work, lower the fork to the ground.
- 6) Before starting inspection work, turn the starting switch OFF and pull out the key.
- 7) Turn the starting switch OFF and keep the key pulled out unless necessary.
- 8) Pull the parking brake lever and put chocks in front and rear of the front and rear tires.

⚠ Precautions for inspection and maintenance work (safety)

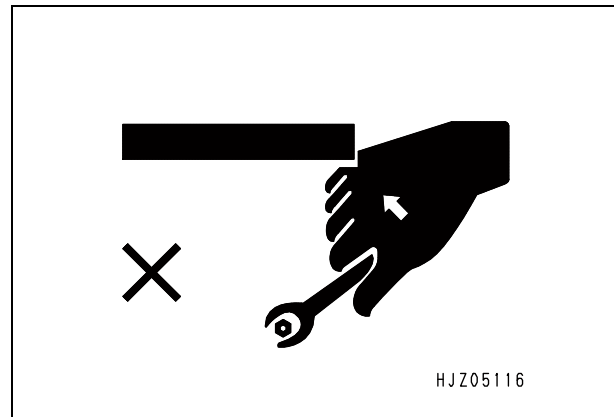
- 1) If oil or grease is sticking, wipe it off. If oil leaks, wipe it off immediately. Dirtiness hides faults such as a crack. Keep clean.
- 2) No fire. Cloths impregnated with fuel or oil can catch fire.
- 3) Wear adequate working clothes.
- 4) Use safety goods and protective items (helmet, safety shoes, goggles and gloves) suitable for work.
- 5) When working on the lift truck, take care not to fall.
- 6) Do not put your foot under the fork.
- 7) When opening and closing the floor plate or engine hood, take care not to have your hand caught.
- 8) When inspecting with the fork raised, pat a stand under the inner mast so that the fork and mast will not fall.
- 9) When working with other personnel, appoint a leader and follow his/her instructions.

⚠ Periodic inspection of safety-critical parts

- 1) Replace the safety-critical parts periodically, even if they are normal.
They are deteriorated as the time passes on and can cause a fire and a trouble in the work equipment system.
- 2) Replace safety-critical parts even before their periodic replacement periods, if they are abnormal.

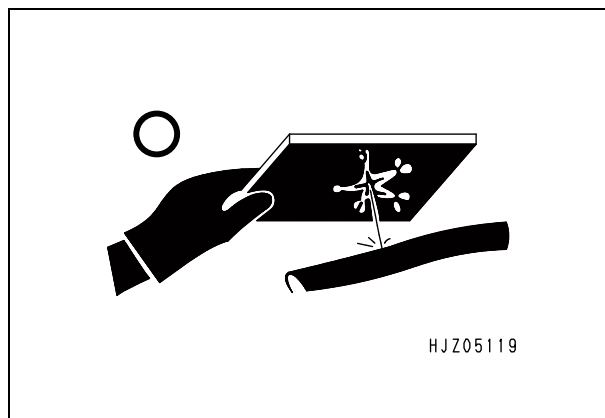
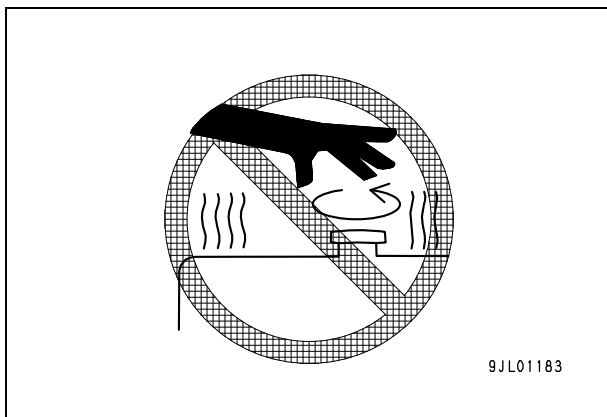
⚠ Use of right tools and equipment

Use right tools for inspection and maintenance work. Use of a broken tool or use a tool for a purpose other than its true purpose is very dangerous.



⚠ Be careful of boiling coolant

- 1) The engine coolant is high in temperature and pressure just after the lift truck is used. Do not remove the radiator cap under this condition. Hot coolant will spout and can scald you.
- 2) When removing the radiator cap, loosen it slowly to release the internal pressure.
- 3) When checking the coolant level, stop the engine and wait for it and radiator to cool. If a reservoir tank is installed, check it.
- 4) If a reservoir tank is installed, add coolant in it.



⚠ Prohibition of welding fuel tank

Never weld the fuel tank since it may explode.

⚠ Take care of high-pressure and high-temperature oil

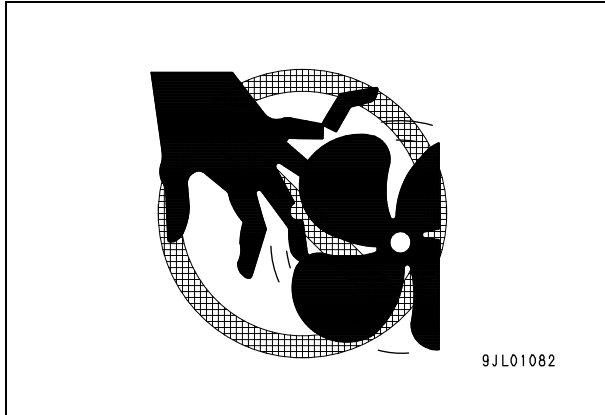
- 1) The oil is high in temperature just after the lift truck is used. Do not drain the oil or replace the oil filter under this condition. Hot oil will spout and can scald you.
- 2) Wait until the oil temperature decreases and then carry out inspection or maintenance according to the procedure described in this manual.
- 3) There is residual pressure in the hydraulic circuit. Do not start inspection or maintenance before the residual pressure decreases to zero.
- 4) High-pressure oil leaking through a small hole is dangerous to the skin or eye. Do not check the hydraulic system for oil leakage with naked eye but put on safety glasses and thick gloves and put a piece of thick paper or plywood to the inspection point.

- 5) When inspecting the accumulator piping, release the pressure inside it in advance.
- 6) If you are injured with high-pressure oil, see a doctor immediately.
- 7) When removing the mast or lift cylinder, be sure to release the pressure from the hydraulic piping.
 - Stop the lift truck and lower the fork to the ground.
 - Stop the engine.
 - Turn the starting switch to the ACC position.
 - Sit on the operator seat and tilt the lift lever and tilt lever forward and in reverse 4 - 5 times each to release the pressure in the hydraulic piping.

⚠ The pressure is not released unless you operate the levers while sitting on the seat.

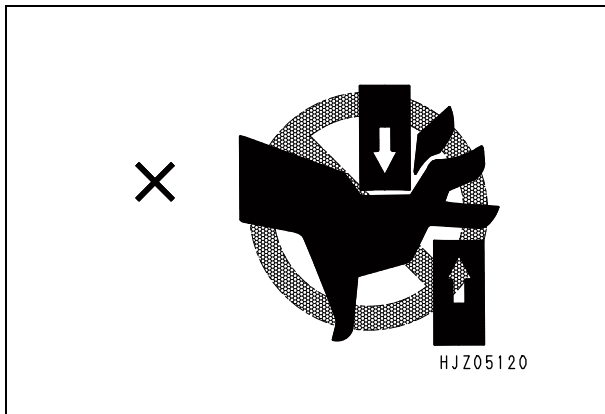
⚠ Beware of rotating cooling fan and belt

- 1) Keep hand off the rotating fan or fan belt.
- 2) When inspecting the rotating parts, stop the engine.
- 3) Do not bring a thing near the rotating parts which can be caught easily.

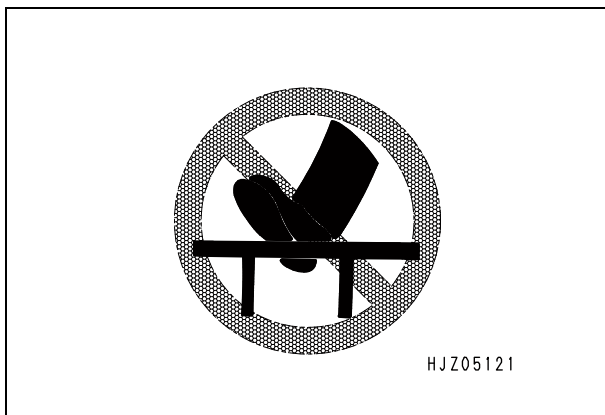


⚠ Danger of being caught and falling

- 1) Never put your hand, foot or body in the mast. You may be caught and injured in the moving parts.

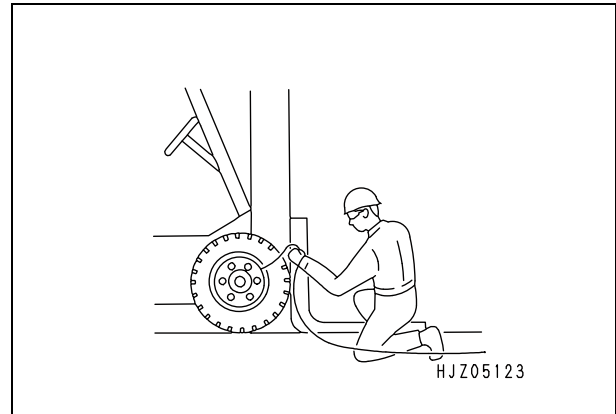


- 2) Do not use the mast as a ladder. You may slip off the mast and fall.



⚠ Tire inspection and inflation procedures

- 1) If the tire inflation pressure is low, the lift truck stability is lowered. Do not inflate the tire immediately, however. The inflation pressure may have decreased because of a damage of the rim. If the tire is inflated to high pressure while the rim is damaged or cracked, the tire will burst and cause an injury or a death.
- 2) When checking the tire inflation pressure, place your body in front of the tread face of the tire. Do not work from the side of the tire.

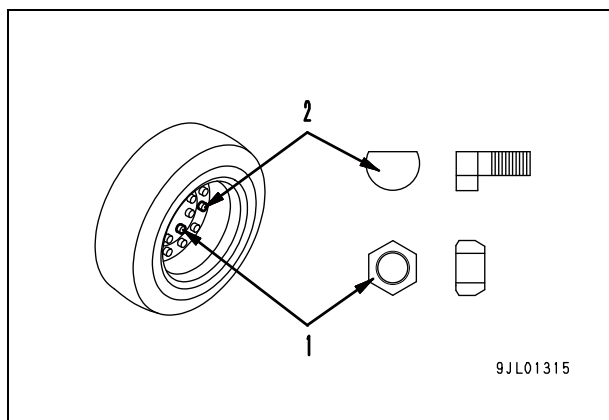


- 3) When inflating the tire, you have to have taken the special education.
- 4) The air pressure for the lift truck tire is as several times high as that for car tire, thus there is possibility of danger in inflating.
- 5) When pumping air into the tire, dirt may be blown with compressed air and may enter your eye. Put of safety glasses.

⚠ Handling of tires

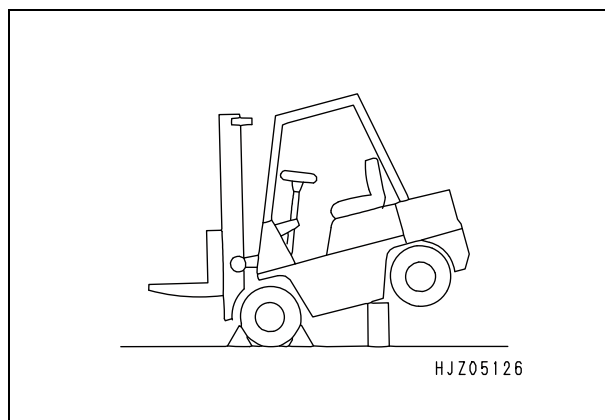
Have the tire disassembled and assembled by a specialist. Since the tire inflation pressure is very high, the tires must be handled carefully.

- 1) When removing the tire, release all air from it. When removing the tire, loosen hub nut (1).
- 2) Never touch rim nut (2). Doing so is dangerous.
- 3) After replacing the tire, travel the lift truck on trial and then check the mounting nuts for looseness. If the tightening torque has decreased, tighten to the specified torque.
- 4) Tightening torque: See "Standard value table".



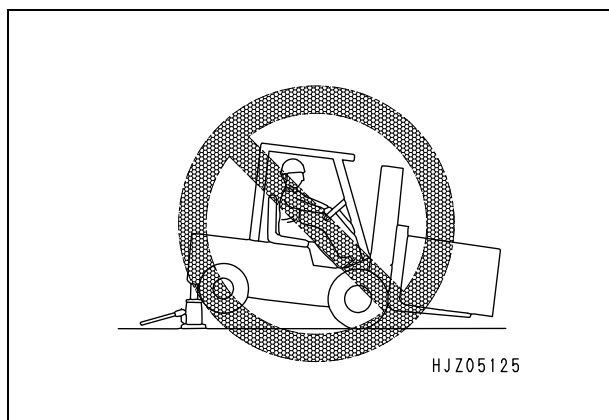
⚠ Slings lift truck (for checking or replacing tire)

- 1) Never sling the lift truck by the overhead guard. When slinging the lift truck frequently, use special slings.
- 2) The lift truck shall be slung by a person who has finished the sling skill course.
- 3) Install wires to the specified slinging points.
- 4) When slinging the lift truck, use wires having sufficient strength and no damage.
- 5) Lock the tires with chocks.
- 6) Put blocks under both sides of the slung lift truck to prevent fall.



⚠ Jack-up work (for checking or replacing tire)

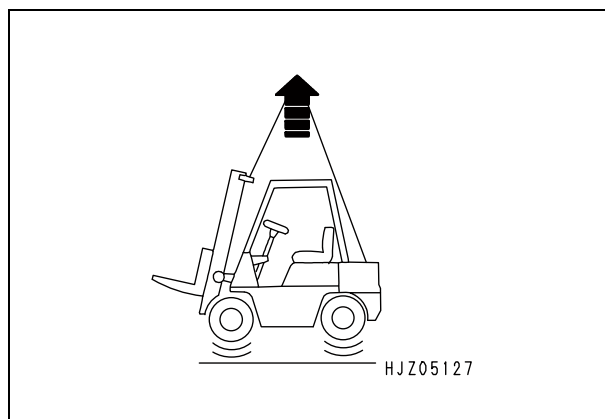
- 1) Do not go under the fork during jack-up work.
- 2) Check the following items before starting jack-up work.
 - No person is on the lift truck.
 - No load is on the lift truck.



- 3) Stop jacking up when the tires are floated above the ground a little and put blocks under both sides of the frame to prevent the lift truck from falling.
- 4) Lock the tires with chocks.

⚠ Slings lift truck (for loading on trailer etc.)

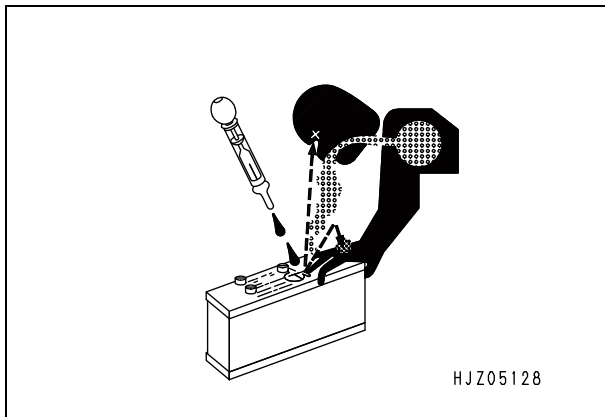
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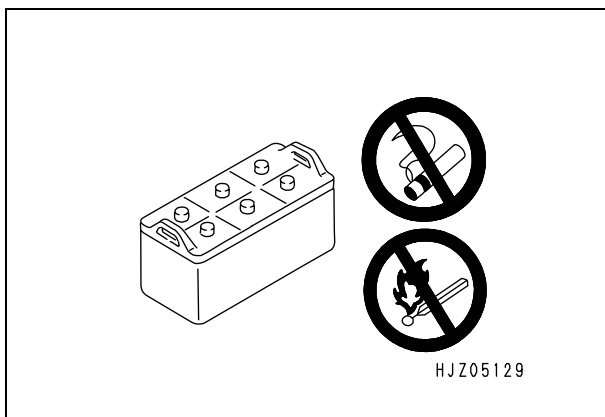
- 4) When slinging the lift truck, use wires having sufficient strength and no damage.

⚠ Handling of batteries

- 1) Battery electrolyte contains dilute sulfuric acid, which attacks clothes and skins. If it sticks to the clothes or skins, take off the clothes immediately and wash the skins which the electrolyte stuck with tap water and then consult a doctor.
- 2) If battery electrolyte gets into your eyes, flush them immediately with fresh tap water for 10 - 15 minutes continually and then consult a doctor.
- 3) If you have drunk battery electrolyte by accident, either drink a large quantity of water or milk mixed with beaten egg white or salad oil, and then consult a doctor at once.



- 4) When handling the battery, always wear safety glasses.
- 5) The battery generates hydrogen gas, which is highly explosive. Do not bring fire of a lighter or a cigarette or make a spark near the battery.



- 6) When inspecting or handling the battery, turn the starting switch OFF.
- 7) When removing the battery, be sure to disconnect the cable from the negative terminal first.

- 8) When installing the battery, be sure to connect the cable to the positive terminal first.
- 9) Do not short the battery terminals by a metallic thing.
- 10) If the terminals are loosened, sparks are made because of a defective contact and they can cause explosion. Tighten the terminals securely.
- 11) When removing the battery, check its positive and negative terminals and take care not to reconnect the cables with reverse polarities.
- 12) Tighten the battery caps securely.
- 13) When cleaning, keep the battery caps tightened.

⚠ Do not put a metallic piece on the battery.
Do not put a metallic piece on the battery, since it can cause a fire from a short circuit.

⚠ Precautions for charging

Nitrogen gas is produced while the battery is being charge and the battery heats itself because of the chemical reaction. To prevent gas explosion, observe the following.

- 1) Charge the battery in a place ventilated well.
- 2) No fire.
- 3) Start to charge the battery when its electrolyte temperature is 35°C or below. (If the electrolyte temperature increases above 50°C, wait until it decreases to below 35°C and then start charging again.)
- 4) When charging the battery with a charging device, keep the battery caps removed.

⚠ Starting engine with booster cables

- 1) When starting the engine with booster cables, put on safety glasses.
- 2) When starting the engine with the battery of another vehicle, do not bring the lift truck body in contact with that vehicle.
- 3) Stop the engine before connecting the cables.
- 4) Take extreme care that the cables will not be caught in the cooling fan or the fan belt.
- 5) Do not make a mistake in connection of the booster cable. Never bring the positive and negative terminals in contact with each other.

⚠ Prohibition of engine push-start

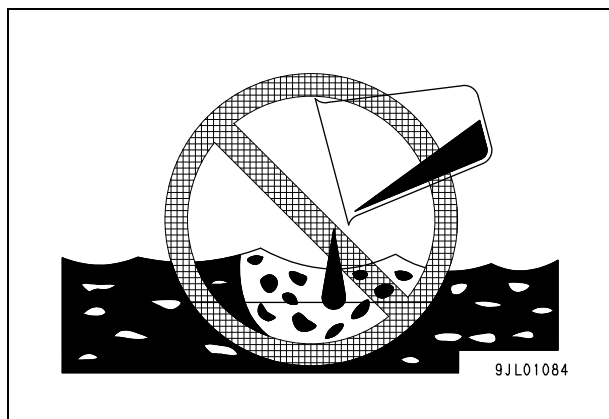
Do not start the engine by pushing the lift truck. The lift truck starts suddenly and you may make a mistake in operation.

⚠ Handling of antifreeze

- 1) Antifreeze contains flammable material. When handling it, do not bring fire near it.
- 2) Since antifreeze is toxic, do not drink it. If you have swallowed by mistake, drink much water and vomit and then consult a doctor immediately.

⚠ Wastes

When disposing of oil, fuel, coolant, solvent, filter, battery, Freon (air conditioner refrigerant), etc., observe the applicable regulations and rules.

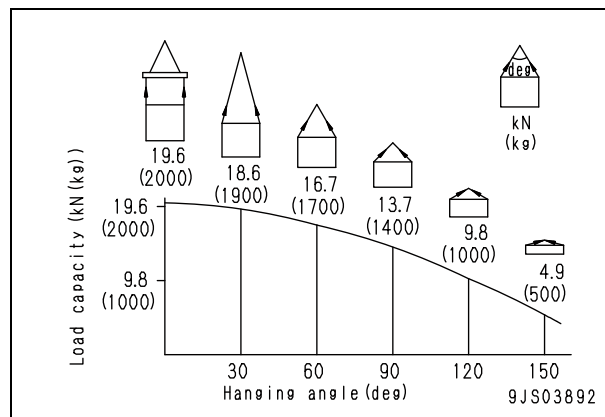


5. Precautions for sling work and making signs

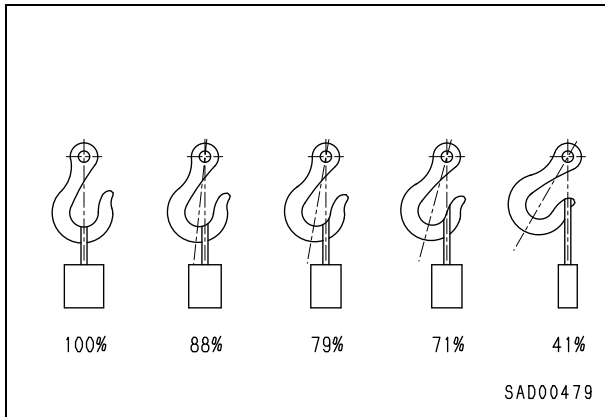
- 1) Only one appointed worker must make signs and co-workers must communicate with each other frequently. The appointed sign maker must make specified signs clearly at a place where he is seen well from the operator's seat and where he can see the working condition easily. The sign maker must always stand in front of the load and guide the operator safely.
 - Do not stand under the load.
 - Do not step on the load.
- 2) Check the slings before starting sling work.
- 3) Keep putting on gloves during sling work. (Put on leather gloves, if available.)
- 4) Measure the weight of the load by the eye and check its center of gravity.
- 5) Use proper sling according to the weight of the load and method of slinging. If too thick wire ropes are used to sling a light load, the load may slip and fall.
- 6) Do not sling a load with 1 wire rope alone. If it is slung so, it may rotate and may slip out of the rope. Install 2 or more wire ropes symmetrically.

⚠ Slings with 1 rope may cause turning of the load during hoisting, untwisting of the rope, or slipping of the rope from its original winding position on the load, which can result in a dangerous accident.

- 7) Limit the hanging angle to 60°, as a rule. Do not sling a heavy load with ropes forming a wide hanging angle from the hook. When hoisting a load with 2 or more ropes, the force subjected to each rope will increase with the hanging angle. The table below shows the variation of allowable load in kN {kg} when hoisting is made with 2 ropes, each of which is allowed to sling up to 9.8 kN {1,000 kg} vertically, at various hanging angles. When the 2 ropes sling a load vertically, up to 19.6 kN {2,000 kg} of total weight can be suspended. This weight is reduced to 9.8 kN {1,000 kg} when the 2 ropes make a hanging angle of 120°. If the 2 ropes sling a 19.6 kN {2,000 kg} load at a lifting angle of 150°, each of them is subjected to a force as large as 39.2 kN {4,000 kg}.



- 8) When installing wire ropes to an angular load, apply pads to protect the wire ropes. If the load is slippery, apply proper material to prevent the wire rope from slipping.
- 9) Use the specified eyebolts and fix wire ropes, chains, etc. to them with shackles, etc.
- 10) Apply wire ropes to the middle portion of the hook.
 - Slings near the tip of the hook may cause the rope to slip off the hook during hoisting. The hook has the maximum strength at the middle portion.



- 11) Do not use twisted or kinked wire ropes.
- 12) When lifting up a load, observe the following.
 - Wind in the crane slowly until wire ropes are stretched. When settling the wire ropes with the hand, do not grasp them but press them from above. If you grasp them, your fingers may be caught.
 - After the wire ropes are stretched, stop the crane and check the condition of the slung load, wire ropes, and pads.
 - If the load is unstable or the wire rope or chains are twisted, lower the load and lift it up again.
 - Do not lift up the load slantingly.
- 13) When lifting down a load, observe the following.
 - When lifting down a load, stop it temporarily at 30 cm above the floor, and then lower it slowly.
 - Check that the load is stable, and then remove the sling.
 - Remove kinks and dirt from the wire ropes and chains used for the sling work, and put them in the specified place.

6. Precautions for using overhead hoist crane

⚠ When raising a heavy part (heavier than 25 kg), use a hoist, etc. In Disassembly and assembly, the weight of a part heavier than 25 kg is indicated after the mark of .

- 1) Before starting work, inspect the wire ropes, brake, clutch, controller, rails, over wind stop device, electric shock prevention earth leakage breaker, crane collision prevention device, and power application warning lamp, and check safety.
- 2) Observe the signs for sling work.
- 3) Operate the hoist at a safe place.
- 4) Check the direction indicator plates (east, west, south, and north) and the directions of the control buttons without fail.
- 5) Do not sling a load slantingly. Do not move the crane while the slung load is swinging.
- 6) Do not raise or lower a load while the crane is moving longitudinally or laterally.
- 7) Do not drag a sling.
- 8) When lifting up a load, stop it just after it leaves the ground and check safety, and then lift it up.
- 9) Consider the travel route in advance and lift up a load to a safe height.
- 10) Place the control switch on a position where it will not be an obstacle to work and passage.
- 11) After operating the hoist, do not swing the control switch.
- 12) Remember the position of the main switch so that you can turn off the power immediately in an emergency.
- 13) If the hoist stops because of a power failure, turn the power switch OFF. When turning on a switch which was turned OFF by the electric shock prevention earth leakage breaker, check that the devices related to that switch are not in operation state.
- 14) If you find an obstacle around the hoist, stop the operation.
- 15) After finishing the work, stop the hoist at the specified position and raise the hook to at least 2 m above the floor. Do not leave the sling installed to the hook.

7. Selecting wire ropes

- 1) Select adequate ropes depending on the weight of parts to be hoisted, referring to the table below.

Wire ropes (Standard "Z" twist ropes without galvanizing) (JIS G3525, No. 6, Type 6X37-A)		
Nominal diameter of rope	Allowable load	
mm	kN	ton
10	8.8	0.9
12	12.7	1.3
14	17.3	1.7
16	22.6	2.3
18	28.6	2.9
20	35.3	3.6
25	55.3	5.6
30	79.6	8.1
40	141.6	14.4
50	221.6	22.6
60	318.3	32.4

- ★ The allowable load is one-sixth of the breaking strength of the rope used (Safety coefficient: 6).

8. Precautions for disconnecting and connecting hoses and tubes in air conditioner circuit

1) Disconnection

⚠ The air conditioner mounted on this lift truck uses refrigerant (R134a), which must not be discharged into the atmosphere as it is, although it has less ozone layer breaking factors for preservation of the environment. When disconnecting the air conditioner gas circuit, be sure to collect the refrigerant to reuse it.

- ★ Ask professional traders for collecting and filling operation of refrigerant (R134a).

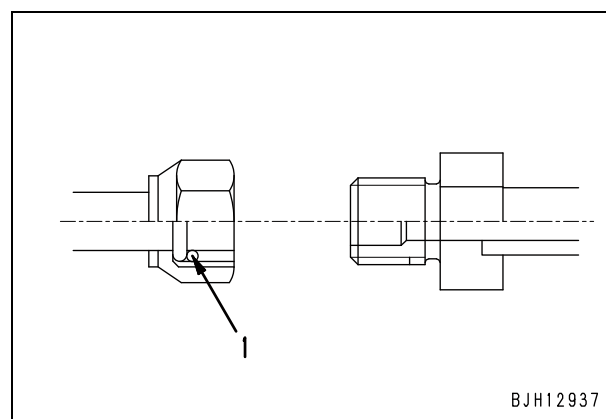
- ★ Never release the refrigerant (R134a) to the atmosphere.

⚠ If the refrigerant gas (R134a) gets in your eyes, you may lose your sight. When collecting or filling the it, be sure to put on protective goggles, gloves and protective clothes. In addition, you must be qualified for handling the refrigerant.

2) Connection

- 1] When installing the air conditioner circuit hoses and tubes, take care that dirt, dust, water, etc. will not enter them.
- 2] When connecting the air conditioner hoses and tubes, check that O-rings (1) are fitted to their joints.
- 3] Check that each O-ring is not damaged or deteriorated.
- 4] When connecting the refrigerant piping, apply compressor oil for refrigerant (R134a) (**DENSO: ND-OIL8, VALEO THERMAL SYSTEMS: ZXL100PG (equivalent to PAG46)**) to its O-rings.

- ★ Example of O-ring (Fitted to every joint of hoses and tubes))



- ★ For tightening torque, see the precautions for installation in each section of "Disassembly and assembly"

How to read the shop manual

- Some attachments and optional parts in this shop manual may not be delivered to certain areas. If one of them is required, consult KOMATSU FORKLIFT distributors.
- Materials and specifications are subject to change without notice.
- Shop manuals are divided into the “Chassis volume” and “Engine volume”. For the engine unit, refer to engine shop manual SM204.

1. Composition of shop manual

This shop manual contains the necessary technical information for services performed in a workshop. For ease of understanding, the manual is divided into the following sections.

00. Foreword

This section explains the shop manuals list, safety, and basic information.

01. Specification

This section explains the specifications of the lift truck.

10. Structure, function and maintenance standard

This section explains the structure, function, and maintenance standard values of each component. The structure and function sub-section explains the structure and function of each component. It serves not only to give an understanding of the structure, but also serves as reference material for troubleshooting. The maintenance standard sub-section explains the criteria and remedies for disassembly and service.

20. Standard value table

This section explains the standard values for new machine and judgement criteria for testing, adjusting, and troubleshooting. This standard value table is used to check the standard values in testing and adjusting and to judge parts in troubleshooting.

30. Testing and adjusting

This section explains measuring instruments and measuring methods for testing and adjusting, and method of adjusting each part. The standard values and judgement criteria for testing and adjusting are explained in Testing and adjusting.

40. Troubleshooting

This section explains how to find out failed parts and how to repair them. The troubleshooting is divided by failure modes. For troubleshooting “S mode” related to the engine, see Engine.

50. Disassembly and assembly

This section explains the special tools and procedures for removing, installing, disassembling, and assembling each component, as well as precautions for them. In addition, tightening torque and quantity and weight of coating material, oil, grease, and coolant necessary for the work are also explained.

80. Yearly inspection criteria

This section explains the items, contents and criteria of the specific self-imposed inspection.

90. Diagrams and drawings (Chassis)

This section gives hydraulic circuit diagrams and electrical circuit diagrams.

2. Symbols

Important safety and quality portions are marked with the following symbols so that the shop manual will be used practically.

Symbol	Item	Remarks
	Security	Special precautions are necessary for lift truck security during assembly work.
	Safety	Special safety precautions are necessary when performing work.
	Caution	Special technical precautions or other precautions for preserving standards are necessary when performing work.
	Weight	Weight of parts of component or parts. Caution necessary when selecting hoisting wire, or when working posture is important, etc.
	Tightening torque	Places that require special attention for tightening torque during assembly.
	Coat	Places to be coated with adhesives, etc. during assembly.
	Oil, coolant	Places where oil, etc. must be added, and capacity.
	Drain	Places where oil, etc. must be drained, and quantity to be drained.

3. Unit

In this shop manual, the units are indicated with International System of units (SI). For reference, conventionally used Gravitational System of units is indicated in parentheses { }.

Explanation of terms for maintenance standard

The chapter of maintenance standard explains the criteria for replacing or reusing each product or part in the disassembly maintenance. The criteria are described by the following terms.

1. Standard size and tolerance

- To be accurate, the finishing size of parts is a little different from one to another.
- To specify a finishing size of a part, a temporary standard size is set and an allowable difference from that size is indicated.
- The above size set temporarily is called the “standard size” and the range of difference from the standard size is called the “tolerance”.
- The tolerance with the symbols of + or - is indicated on the right side of the standard size.

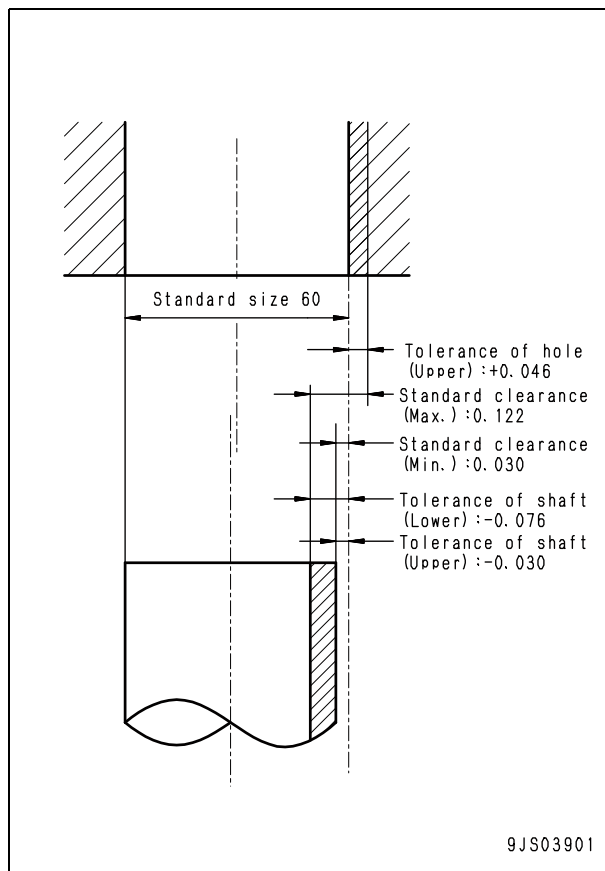
Example:

Standard size	Tolerance
120	-0.022 -0.126

- ★ The tolerance may be indicated in the text and a table as [standard size (upper limit of tolerance/lower limit of tolerance)].
Example) 120 (-0.022/-0.126)
- Usually, the size of a hole and the size of the shaft to be fitted to that hole are indicated by the same standard size and different tolerances of the hole and shaft. The tightness of fit is decided by the tolerance.
- Indication of size of rotating shaft and hole and relationship drawing of them

Example:

Standard size	Tolerance	
	Shaft	Hole
60	-0.030 -0.076	+0.046 0



2. Standard clearance and standard value

- The clearance made when new parts are assembled is called the “standard clearance”, which is indicated by the range from the minimum clearance to the maximum clearance.
- When some parts are repaired, the clearance is generally adjusted to the standard clearance.
- A value of performance and function of new products or equivalent is called the “standard value”, which is indicated by a range or a target value.
- When some parts are repaired, the value of performance/function is set to the standard value.

3. Standard interference

- When the diameter of a hole of a part shown in the given standard size and tolerance table is smaller than that of the mating shaft, the difference between those diameters is called the “interference”.
- The range (A - B) from the difference (A) between the minimum size of the shaft and the maximum size of the hole to the difference (B) between the maximum size of the shaft and the minimum size of the hole is the “standard interference”.
- After repairing or replacing some parts, measure the size of their hole and shaft and check that the interference is in the standard range.

4. Repair limit and allowable value or allowable dimension

- The size of a part changes because of wear and deformation while it is used. The limit of changed size is called the “repair limit”.
- If a part is worn to the repair limit must be replaced or repaired.
- The performance and function of a product lowers while it is used. A value below which the product can be used without causing a problem is called the “allowable value” or “allowable dimension”.
- If a product is worn to the allowable value, it must be checked or repaired. Since the permissible value is estimated from various tests or experiences in most cases, however, it must be judged after considering the operating condition and customer's requirement.

5. Clearance limit

- Parts can be used until the clearance between them is increased to a certain limit. The limit at which those parts cannot be used is called the “clearance limit”.
- If the clearance between the parts exceeds the clearance limit, they must be replaced or repaired.

6. Interference limit

- The allowable maximum interference between the hole of a part and the shaft of another part to be assembled is called the “interference limit”.
- The interference limit shows the repair limit of the part of smaller tolerance.
- If the interference between the parts exceeds the interference limit, they must be replaced or repaired.

Handling of electric equipment and hydraulic component

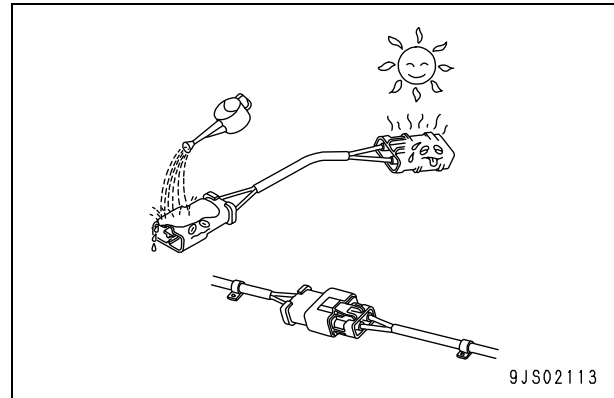
To maintain the performance of the machine over a long period, and to prevent failures or other troubles before they occur, correct “operation”, “maintenance and inspection”, “troubleshooting”, and “repairs” must be carried out. This section deals particularly with correct repair procedures for mechatronics and is aimed at improving the quality of repairs. For this purpose, it gives sections on “Handling electric equipment” and “Handling hydraulic equipment” (particularly gear oil and hydraulic oil).

Points to remember when handling electric equipment

1. Handling wiring harnesses and connectors

Wiring harnesses consist of wiring connecting one component to another component, connectors used for connecting and disconnecting one wire from another wire, and protectors or tubes used for protecting the wiring.

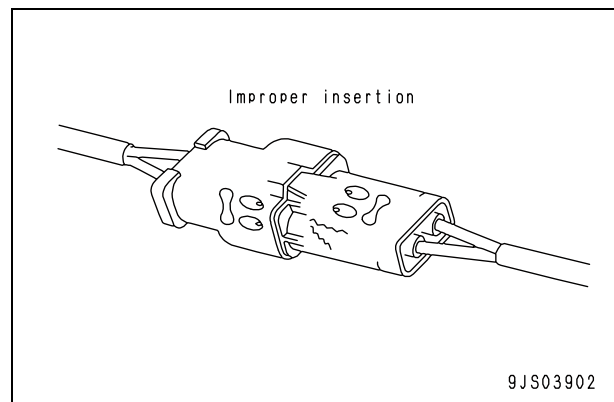
Compared with other electrical components fitted in boxes or cases, wiring harnesses are more likely to be affected by the direct effects of rain, water, heat, or vibration. Furthermore, during inspection and repair operations, they are frequently removed and installed again, so they are likely to suffer deformation or damage. For this reason, it is necessary to be extremely careful when handling wiring harnesses.



2. Main failures occurring in wiring harness

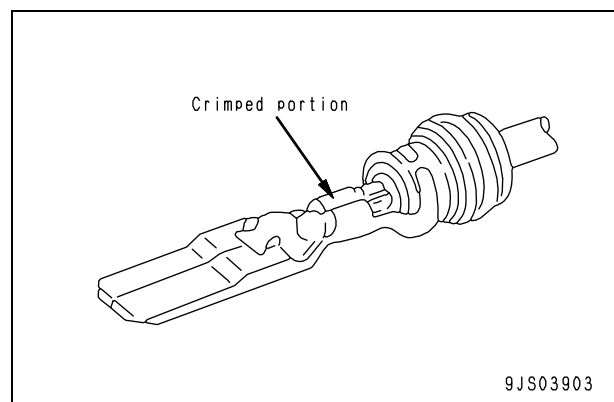
1) Defective contact of connectors (defective contact between male and female)

Problems with defective contact are likely to occur because the male connector is not properly inserted into the female connector, or because one or both of the connectors is deformed or the position is not correctly aligned, or because there is corrosion or oxidation of the contact surfaces. The corroded or oxidized contact surfaces may become shiny again (and contact may become normal) by connecting and disconnecting the connector about 10 times.



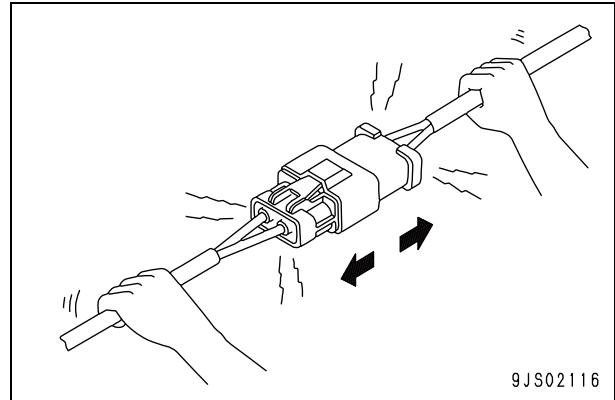
2) Defective crimping or soldering of connectors

The pins of the male and female connectors are in contact at the crimped terminal or soldered portion, but if there is excessive force brought to bear on the wiring, the plating at the joint will peel and cause improper connection or breakage.



3) Disconnections in wiring

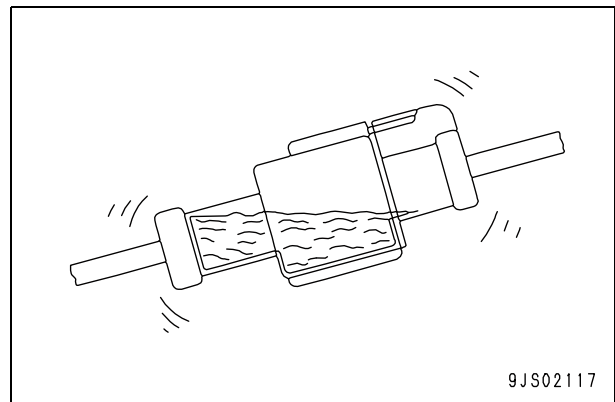
If the wiring is held and the connectors are pulled apart, or components are lifted with a crane with the wiring still connected, or a heavy object hits the wiring, the crimping of the connector may separate, or the soldering may be damaged, or the wiring may be broken.



4) High-pressure water entering connector

The connector is designed to make it difficult for water to enter (drip-proof structure), but if high-pressure water is sprayed directly on the connector, water may enter the connector, depending on the direction of the water jet. Accordingly, take care not to splash water over the connector.

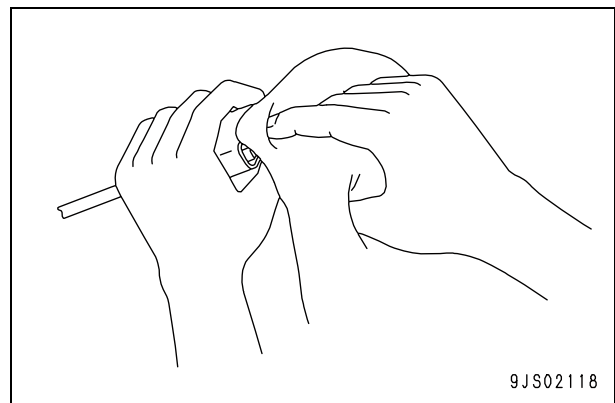
The connector is designed to prevent water from entering, but at the same time, if water does enter, it is difficult for it to be drained. Therefore, if water should get into the connector, the pins will be short-circuited by the water, so if any water gets in, immediately dry the connector or take other appropriate action before passing electricity through it.



5) Oil or dirt stuck to connector

If oil or grease are stuck to the connector and an oil film is formed on the mating surface between the male and female pins, the oil will not let the electricity pass, so there will be defective contact. If there is oil or grease stuck to the connector, wipe it off with a dry cloth or blow it dry with compressed air and spray it with a contact restorer.

- ★ When wiping the mating portion of the connector, be careful not to use excessive force or deform the pins.
- ★ If there is oil or water in the compressed air, the contacts will become even dirtier, so remove the oil and water from the compressed air completely before cleaning with compressed air.



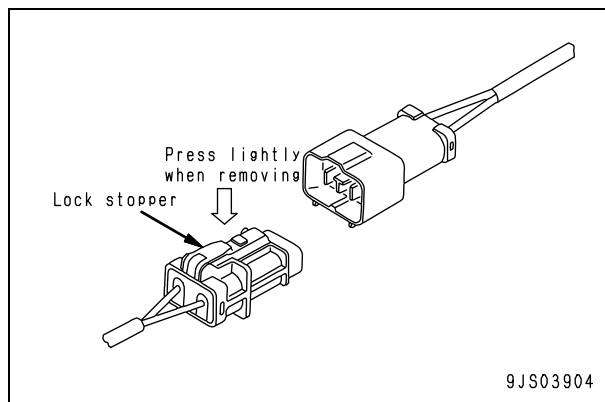
3. Removing, installing, and drying connectors and wiring harnesses

1) Disconnecting connectors

- 1] Hold the connectors when disconnecting.

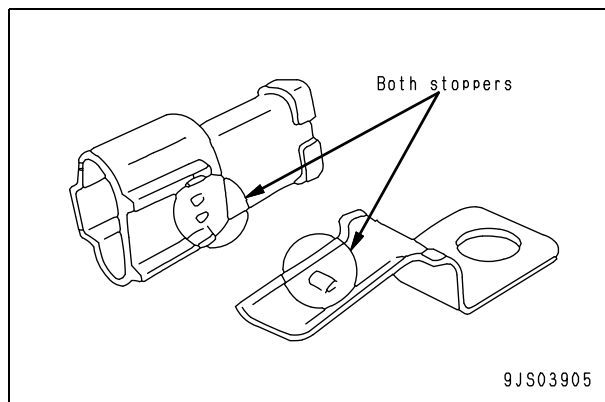
When disconnecting the connectors, hold the connectors. For connectors held by a screw, loosen the screw fully, then hold the male and female connectors in each hand and pull apart. For connectors which have a lock stopper, press down the stopper with your thumb and pull the connectors apart.

★ Never pull with one hand.



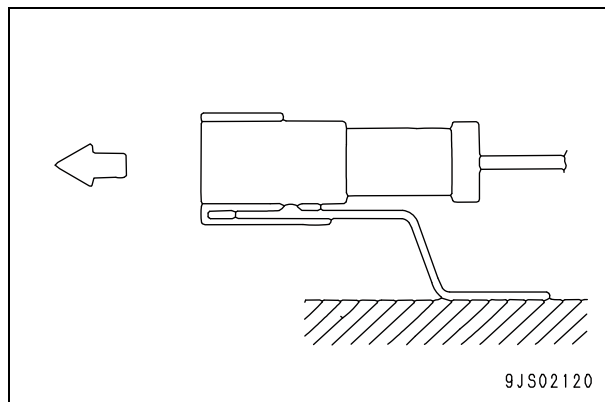
- 2] When removing from clips

- Both of the connector and clip have stoppers, which are engaged with each other when the connector is installed.

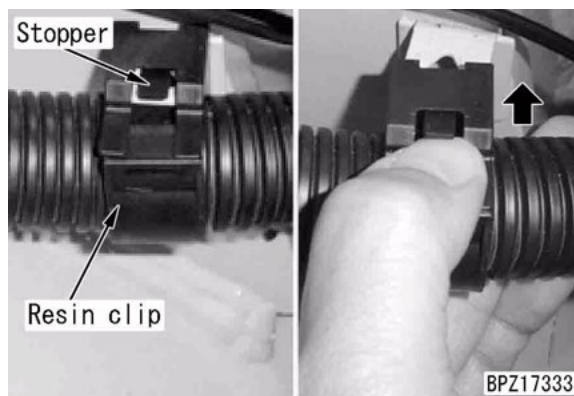


- When removing a connector from a clip, pull the connector in a parallel direction to the clip for removing stoppers.

★ If the connector is twisted up and down or to the left or right, the housing may break.

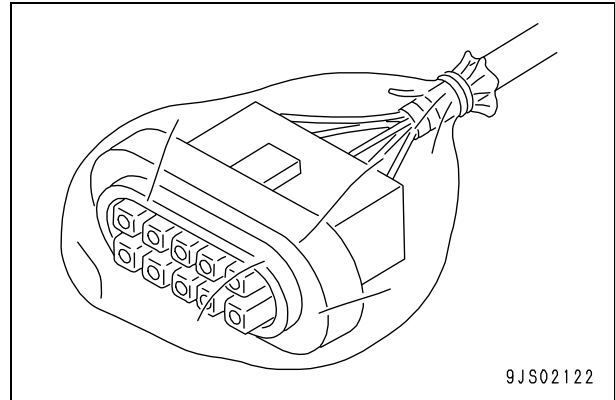


- ★ Removal of resin clip
Lift up the stopper of range clip, and then pull out the range clip.



- 3] Action to take after removing connectors
After removing any connector, cover it with a vinyl bag to prevent any dust, dirt, oil, or water from getting in the connector portion.

★ If the machine is left disassembled for a long time, it is particularly easy for improper contact to occur, so always cover the connector.



2) Connecting connectors

- 1] Check the connector visually.
Check that there is no oil, dirt, or water stuck to the connector pins (mating portion).

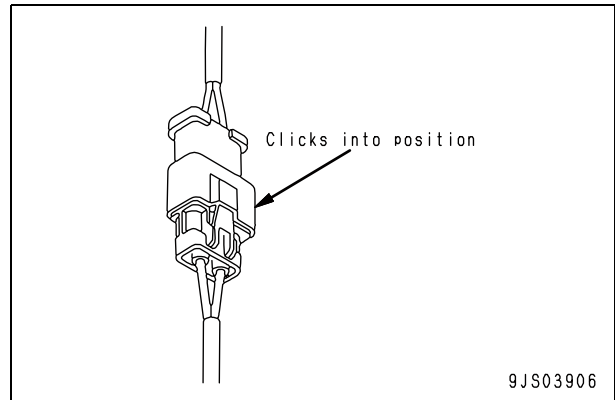
Check that there is no deformation, defective contact, corrosion, or damage to the connector pins.

Check that there is no damage or breakage to the outside of the connector.

★ If there is any oil, water, or dirt stuck to the connector, wipe it off with a dry cloth. If any water has got inside the connector, warm the inside of the wiring with a dryer, but be careful not to make it too hot as this will cause short circuits.

★ If there is any damage or breakage, replace the connector.

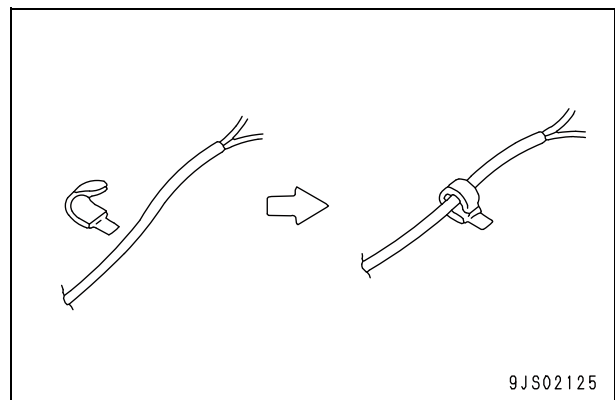
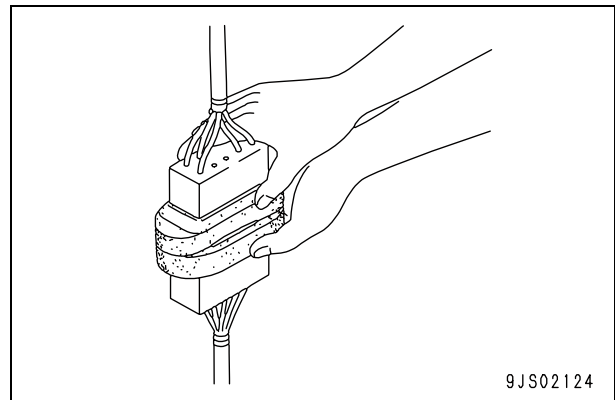
- 2] Fix the connector securely.
Align the position of the connector correctly, and then insert it securely. For connectors with the lock stopper, push in the connector until the stopper clicks into position.



- 3] Correct any protrusion of the boot and any misalignment of the wiring harness.
For connectors fitted with boots, correct any protrusion of the boot. In addition, if the wiring harness is misaligned, or the clamp is out of position, adjust it to its correct position.

★ If the connector cannot be corrected easily, remove the clamp and adjust the position.

- If the connector clamp has been removed, be sure to return it to its original position. Check also that there are no loose clamps.



3) Heavy duty wire connector (DT 8-pole, 12-pole)

Disconnection (Left of figure)

While pressing both sides of locks (a) and (b), pull out female connector (2).

Connection (Right of figure)

1] Push in female connector (2) horizontally until the lock clicks.

Arrow: 1)

2] Since locks (a) and (b) may not be set completely, push in female connector (2) while moving it up and down until the locks are set normally.

Arrow: 1), 2), 3)

★ Right of figure: Lock (a) is pulled down (not set completely) and lock (b) is set completely.

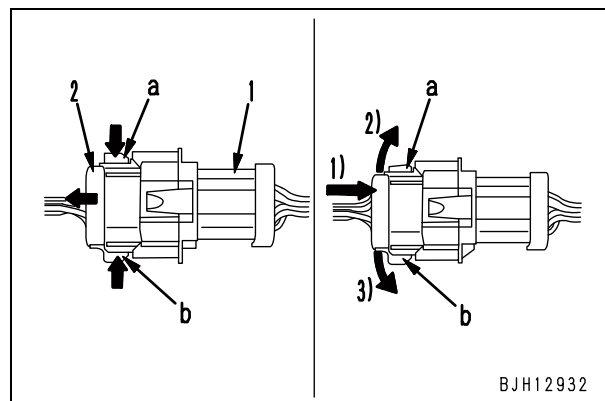
(1): Male connector

(2): Female connector

(a), (b): Locks

• Disconnection

• Connection (Example of incomplete setting of (a))



4) Drying wiring harness

If there is any oil or dirt on the wiring harness, wipe it off with a dry cloth. Avoid washing it in water or using steam. If the connector must be washed in water, do not use high-pressure water or steam directly on the wiring harness. If water gets directly on the connector, do as follows.

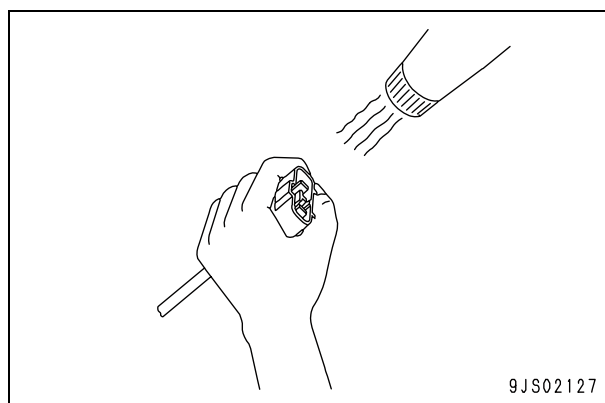
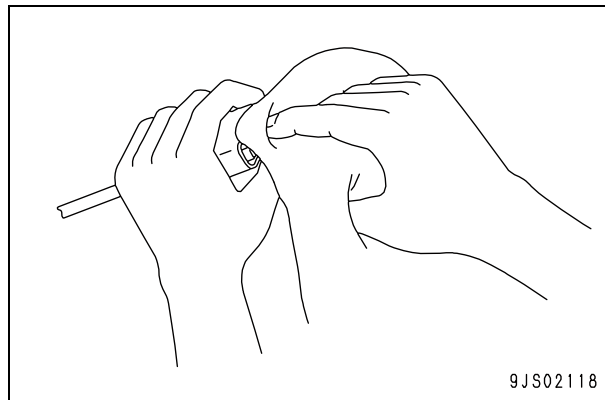
- 1] Disconnect the connector and wipe off the water with a dry cloth.

★ If the connector is blown dry with compressed air, there is the risk that oil in the air may cause defective contact, so remove all oil and water from the compressed air before blowing with air.

- 2] Dry the inside of the connector with a dryer.

If water gets inside the connector, use a dryer to dry the connector.

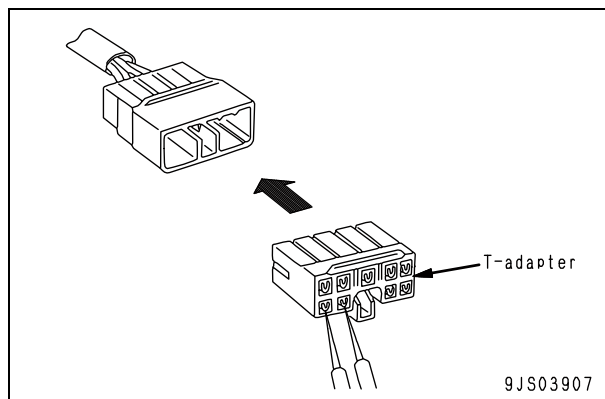
★ Hot air from the dryer can be used, but regulate the time that the hot air is used in order not to make the connector or related parts too hot, as this will cause deformation or damage to the connector.



- 3] Carry out a continuity test on the connector.

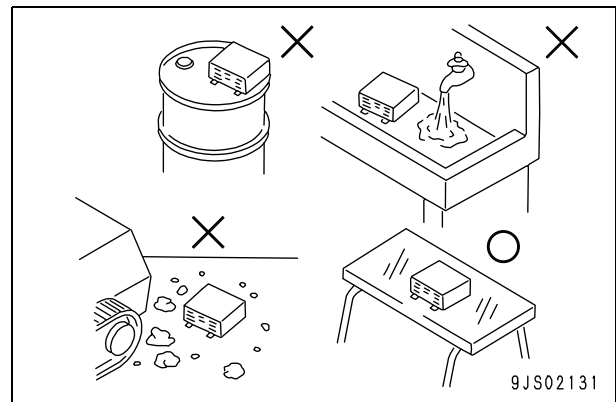
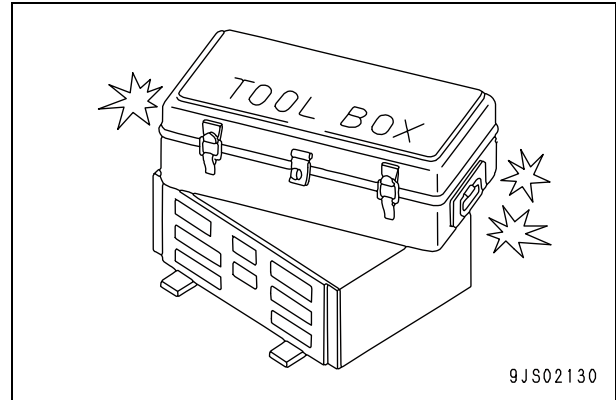
After drying, leave the wiring harness disconnected and carry out a continuity test to check for any short circuits between pins caused by water.

★ After completely drying the connector, blow it with contact restorer and reassemble.



4. Handling controller

- 1) The controller contains a microcomputer and electronic control circuits. microcomputer and electronic control circuits. These control all of the electronic circuits on the machine, so be extremely careful when handling the controller.
- 2) Do not place objects on top of the controller.
- 3) Cover the control connectors with tape or a vinyl bag. Never touch the connector contacts with your hand.
- 4) During rainy weather, do not leave the controller in a place where it is exposed to rain.
- 5) Do not place the controller on oil, water, or soil, or in any hot place, even for a short time. (Place it on a suitable dry stand).
- 6) Precautions when carrying out arc welding
When carrying out arc welding on the body, disconnect all wiring harness connectors connected to the controller. Fit an arc welding ground close to the welding point.



5. Points to remember when troubleshooting electric circuits

- 1) Always turn the power OFF before disconnecting or connecting connectors.
- 2) Before carrying out troubleshooting, check that all the related connectors are properly inserted.
★ Disconnect and connect the related connectors several times to check.
- 3) Always connect any disconnected connectors before going on to the next step.
★ If the power is turned ON with the connectors still disconnected, unnecessary abnormality displays will be generated.
- 4) When carrying out troubleshooting of circuits (measuring the voltage, resistance, continuity, or current), move the related wiring and connectors several times and check that there is no change in the reading of the tester.
★ If there is any change, there is probably defective contact in that circuit.

Points to remember when handling hydraulic equipment

With the increase in pressure and precision of hydraulic equipment, the most common cause of failure is dirt (foreign material) in the hydraulic circuit. When adding hydraulic oil, or when disassembling or assembling hydraulic equipment, it is necessary to be particularly careful.

1. Be careful of the operating environment.

Avoid adding hydraulic oil, replacing filters, or repairing the machine in rain or high winds, or places where there is a lot of dust.

2. Disassembly and maintenance work in the field

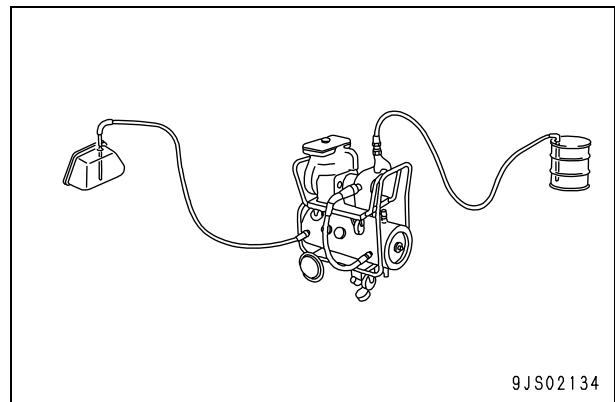
If disassembly or maintenance work is carried out on hydraulic equipment in the field, there is danger of dust entering the equipment. It is also difficult to check the performance after repairs, so it is desirable to use unit exchange. Disassembly and maintenance of hydraulic equipment should be carried out in a specially prepared dust proof workshop, and the performance should be checked with special test equipment.

3. Sealing openings

After any piping or equipment is removed, the openings should be sealed with caps, tapes, or vinyl bags to prevent any dirt or dust from entering. If the opening is left open or is blocked with a rag, there is danger of dirt entering or of the surrounding area being made dirty by leaking oil so never do this. Do not simply drain oil out onto the ground, but collect it and ask the customer to dispose of it, or take it back with you for disposal.

4. Do not let any dirt or dust get in during refilling operations

Be careful not to let any dirt or dust get in when refilling with hydraulic oil. Always keep the oil filler and the area around it clean, and also use clean pumps and oil containers. If an oil cleaning device is used, it is possible to filter out the dirt that has collected during storage, so this is an even more effective method.

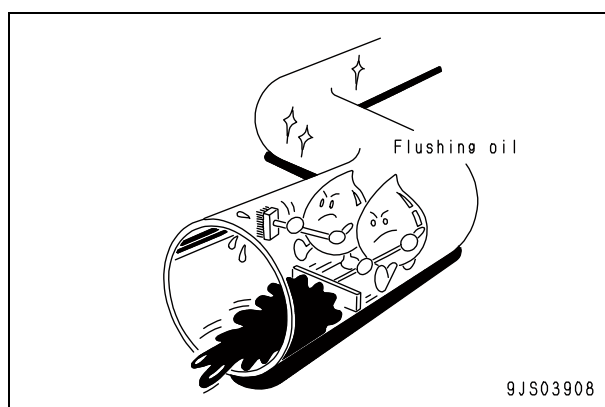


5. Change hydraulic oil when the temperature is high

When hydraulic oil or other oil is warm, it flows easily. In addition, the sludge can also be drained out easily from the circuit together with the oil, so it is best to change the oil when it is still warm. When changing the oil, as much as possible of the old hydraulic oil must be drained out. (Drain the oil from the hydraulic tank; also drain the oil from the filter and from the drain plug in the circuit.) If any old oil is left, the contaminants and sludge in it will mix with the new oil and will shorten the life of the hydraulic oil.

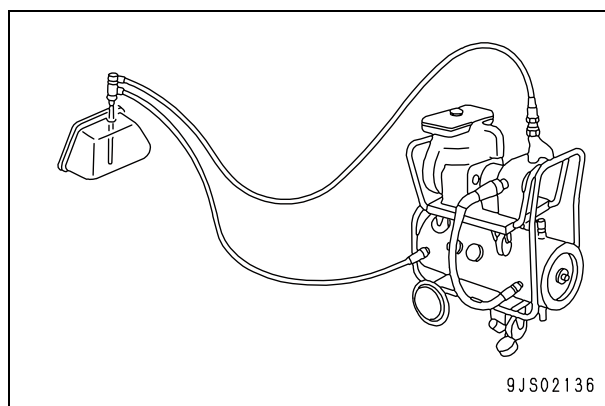
6. Flushing operations

After disassembling and assembling the equipment, or changing the oil, use flushing oil to remove the contaminants, sludge, and old oil from the hydraulic circuit. Normally, flushing is carried out twice: primary flushing is carried out with flushing oil, and secondary flushing is carried out with the specified hydraulic oil.



7. Cleaning operations

After repairing the hydraulic equipment (pump, control valve, etc.) or when running the machine, carry out oil cleaning to remove the sludge or contaminants in the hydraulic oil circuit. The oil cleaning equipment is used to remove the ultra fine (about 3 μ) particles that the filter built in the hydraulic equipment cannot remove, so it is an extremely effective device.



Handling of connectors newly used for engines

★ Mainly, following engines are object for following connectors.

- 95E-5
- 107E-1

1. Slide lock type (FRAMATOME-3, FRAMATOME-2)

- 95E-5 engine, 107E-1 engine
 - Various pressure sensors and NE speed sensor

Example)

Oil pressure switch

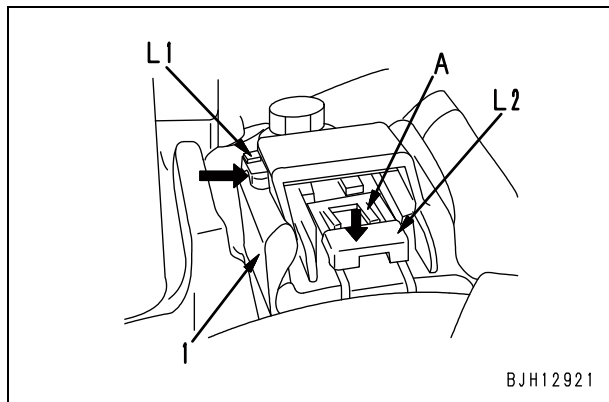
Ne speed sensor of flywheel housing

: NE

Disconnect connector (1) according to the following procedure.

- 1) Slide lock L1 to the right.
- 2) While pressing lock L2, pull out connector (1) toward you.

★ Even if lock L2 is pressed, connector (1) cannot be pulled out toward you, if part A does not float. In this case, float part A with a small screwdriver while pressing lock L2, and then pull out connector (1) toward you.



2. Pull lock type (PACKARD-2)

- 95E-5 engine, 107E-1 engine
 - Various temperature sensors

Example)

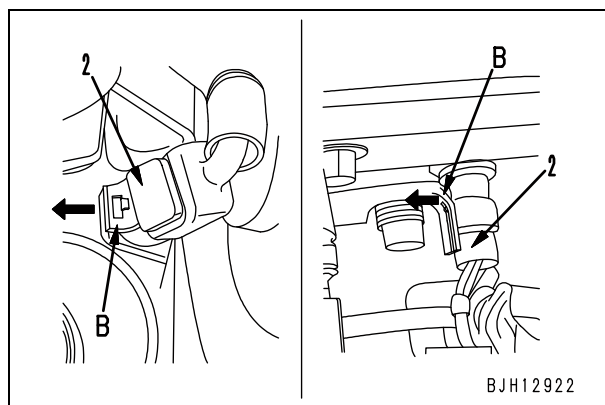
Intake air temperature sensor in intake manifold: TIM

Fuel temperature sensor: TFUEL

Oil temperature sensor: TOIL

Coolant temperature sensor: TWTR, etc.

Disconnect the connector by pulling lock (B) (on the wiring harness side) of connector (2) outward.



3. Push lock type

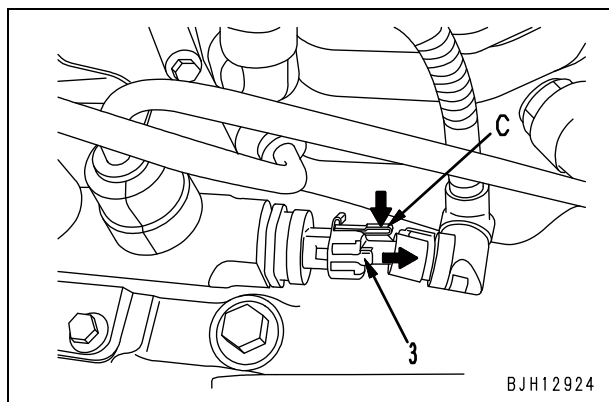
Example)

Fuel pressure sensor in common rail
(**BOSCH-03**)

Disconnect connector (3) according to the following procedure.

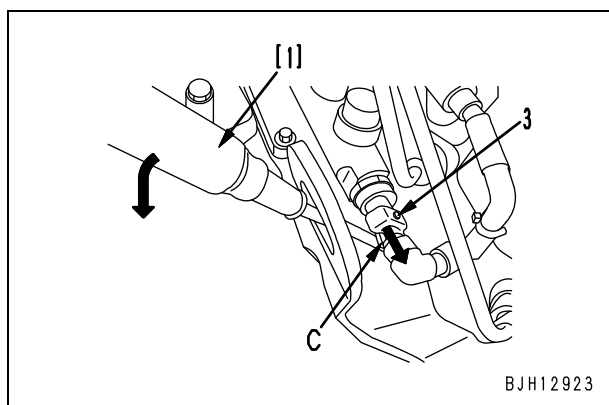
- 1) While pressing lock (C), pull out connector (3) in the direction of the arrow.

- 95E-5 engine, 107E-1 engine



- ★ If the lock is on the underside, use flat-head screwdriver [1] since you cannot insert your fingers.

- 2) While pressing up lock (C) of the connector with flat-head screwdriver [1], pull out connector (3) in the direction of the arrow.

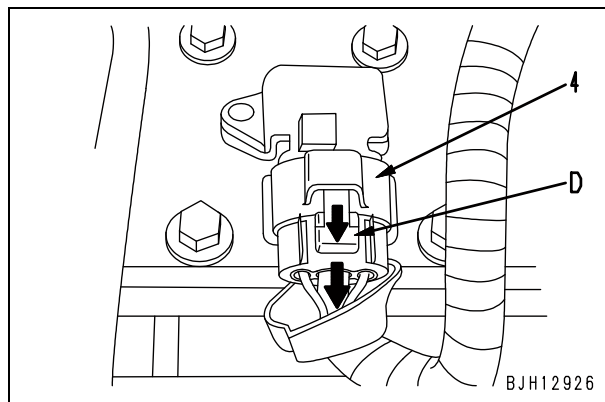


- 107E-1 engine

Example)

Intake air pressure/temperature sensor in intake manifold (**SUMITOMO-04**)

- 3) While pressing lock (D), pull out connector (4) in the direction of the arrow.

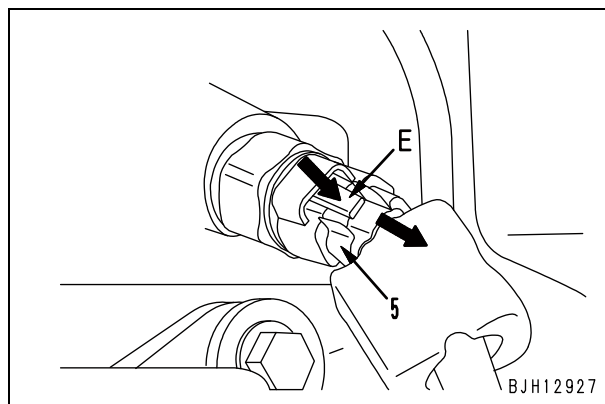


- 95E-5 engine

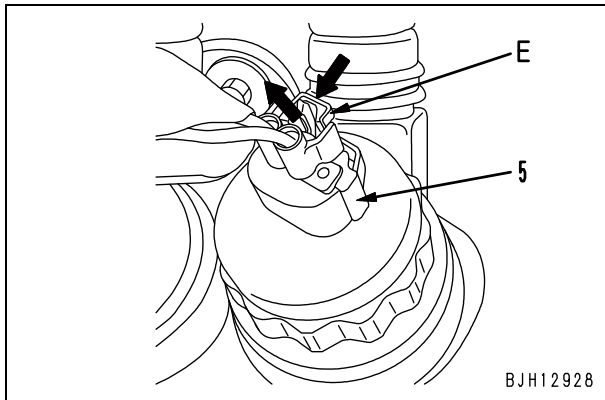
- 4) While pressing lock (E), pull out connector (5) in the direction of the arrow.

Example)

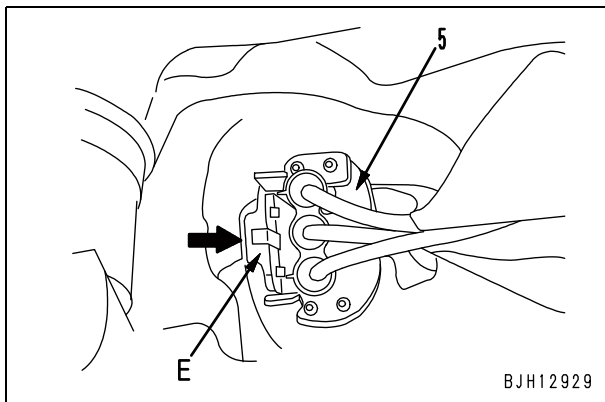
Fuel pressure in common rail: PFUEL etc.
(**AMP-3**)



Example)
Injection pressure control valve of fuel supply
pump: PCV (**SUMITOMO-2**)



Example)
Speed sensor of fuel supply pump:
G (**SUMITOMO-3**)
★ Pull the connector straight up.



How to read electric wire code

In the electric circuit diagram, the material, thickness, and color of each electric wire are indicated by symbols. The electric wire code is helpful in understanding the electric circuit diagram.

Example: 0.85

L

Indicates blue, heat-resistant, low-voltage wire for automobile, having nominal No. of 0.85.

Indicates color of wire by color code.
Color codes are shown in Table 3.

Indicates size of wire by nominal No.
Size (Nominal No.) is shown in Table 2.

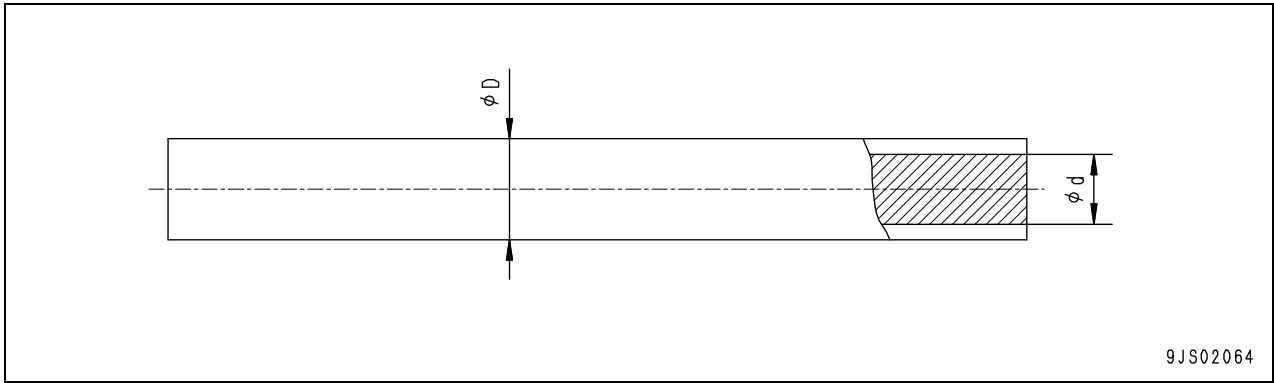
1. Dimensions

(Table 2)

Nominal No.			0.5f	(0.5)	0.75f	(0.85)	1.25f	(1.25)	2f	2	3f	3	5
Conductor	Number of strands/Diameter of strand		20/0.18	7/0.32	30/0.18	11/0.32	50/0.18	16/0.32	37/0.26	26/0.32	58/0.26	41/0.32	65/0.32
	Sectional area (mm ²)		0.51	0.56	0.76	0.88	1.27	1.29	1.96	2.09	3.08	3.30	5.23
	d (approx.)		1.0		1.2		1.5		1.9	1.9	2.3	2.4	3.0
Cover D	AVS	Standard	2.0		2.2		2.5		2.9	2.9	3.5	3.6	–
	AV	Standard	–		–		–		–	–	–	–	4.6
	CAVS	Standard	–	1.6	–	1.8	–	2.1	–	–	–	–	–
	AEX	Standard	2.0		2.2		2.7		3.0	3.1	–	3.8	4.6

Nominal No.			8	15	20	30	40	50	60	85	100
Conductor	Number of strands/Diameter of strand		50/0.45	84/0.45	41/0.80	70/0.80	85/0.80	108/0.80	127/0.80	169/0.80	217/0.80
	Sectional area (mm ²)		7.95	13.36	20.61	35.19	42.73	54.29	63.84	84.96	109.1
	d (approx.)		3.7	4.8	6.0	8.0	8.6	9.8	10.4	12.0	13.6
CoVer D	AVS	Standard	–	–	–	–	–	–	–	–	–
	AV	Standard	5.5	7.0	8.2	10.8	11.4	13.0	13.6	16.0	17.6
	CAVS	Standard	–	–	–	–	–	–	–	–	–
	AEX	Standard	5.3	7.0	8.2	10.8	11.4	13.0	13.6	16.0	17.6

“f” of nominal No. denotes “flexible”.



2. Type, symbol, and material

AV and AVS are different in only thickness and outside diameter of the cover. AEX is similar to AV in thickness and outside diameter of AEX and different from AV and AVS in material of the cover.

(Table 1)

Type	Symbol	Material		Using temperature range (°C)	Example of use
Low-voltage wire for automobile	AV	Conductor	Annealed copper for electric appliance	-30 to +60	Wiring conducting large current (Nominal No. 5 and above)
		Insulator	Soft polyvinyl chloride		
Thin-cover low-voltage wire for automobile, type 1	AVS	Conductor	Annealed copper for electric appliance		General wiring (Nominal No. 0.5 - 3)
		Insulator	Soft polyvinyl chloride		
Thin-cover low-voltage wire for automobile, type 2	CAVS	Conductor	Annealed copper for electric appliance		General wiring (Nominal No. 0.5 - 1.25)
		Insulator	Soft polyvinyl chloride		
Heat-resistant low-voltage wire for automobile	AEX	Conductor	Annealed copper for electric appliance	-50 to +110	General wiring in extremely cold district, wiring at high-temperature place
		Insulator	Heat-resistant crosslinked polyethylene		

3. Color codes table

(Table 3)

Color code	Color of wire	Color code	Color of wire
B	Black	LgW	Light green & White
Br	Brown	LgY	Light green & Yellow
BrB	Brown & Black	LR	Blue & Red
BrR	Brown & Red	LW	Blue & White
BrW	Brown & White	LY	Blue & Yellow
BrY	Brown & Yellow	O	Orange
Ch	Charcoal	P	Pink
Dg	Dark green	R	Red
G	Green	RB	Red & Black
GB	Green & Black	RG	Red & Green
GL	Green & Blue	RL	Red & Blue
Gr	Gray	RW	Red & White
GR	Green & Red	RY	Red & Yellow
GW	Green & White	Sb	Sky Blue
GY	Green & Yellow	Y	Yellow
L	Blue	YB	Yellow & Black
LB	Blue & Black	YG	Yellow & Green
Lg	Light green	YL	Yellow & Blue
LgB	Light green & Black	YR	Yellow & Red
LgR	Light green & Red	YW	Yellow & White

Remarks: In a color code consisting of 2 colors, the first color is the color of the background and the second color is the color of the marking.

Example: "GW" means that the background is Green and marking is White.

4. Types of circuits and color codes

(Table 4)

Type of wire		AVS or AV						AEX	
Type of circuit	Charge	R	WG	—	—	—	—	R	—
	Ground	B	—	—	—	—	—	B	—
	Start	R	—	—	—	—	—	R	—
	Light	RW	RB	RY	RG	RL	—	D	—
	Instrument	Y	YR	YB	YG	YL	YW	Y	Gr
	Signal	G	GW	GR	GY	GB	GL	G	Br
	Others	L	LW	LR	LY	LB	—	L	—
		Br	BrW	BrR	BrY	BrB	—	—	—
		Lg	LgR	LgY	LgB	LgW	—	—	—
		O	—	—	—	—	—	—	—
		Gr	—	—	—	—	—	—	—
		P	—	—	—	—	—	—	—
		Sb	—	—	—	—	—	—	—
		Dg	—	—	—	—	—	—	—
		Ch	—	—	—	—	—	—	—

Precautions when carrying out operation

When carrying out removal, installation, disassembly or assembly of units, be sure to follow the general precautions given below.

1. Precautions when carrying out removal work

- If the coolant contains antifreeze, dispose of it correctly.
 - After disconnecting hoses or tubes, cover them or fit plugs to prevent dirt or dust from entering.
 - When draining oil, prepare a container of adequate size to catch the oil.
 - Confirm the match marks showing the installation position, and make match marks in the necessary places before removal to prevent any mistake when assembling.
 - To prevent any excessive force from being applied to the wiring, always hold the connectors when disconnecting the connectors.
 - Fit wires and hoses with tags to show their installation position to prevent any mistake when installing.
 - Check the number and thickness of the shims, and keep in a safe place.
 - When raising components, be sure to use lifting equipment of ample strength.
 - When using forcing screws to remove any components, tighten the forcing screws uniformly in turn.
 - Before removing any unit, clean the surrounding area and fit a cover to prevent any dust or dirt from entering after removal.
- ★ Precautions when handling piping during disassembly
Fit the following plugs into the piping after disconnecting it during disassembly operations.
- 1) Face seal type hoses and tubes

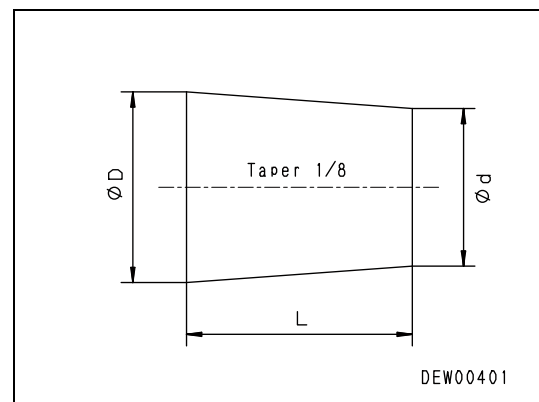
Nominal No.	Plug (nut end)	Nut (elbow end)
02	07376-70210	02789-00210
03	07376-70315	02789-00315
04	07376-70422	02789-00422
05	07376-70522	02789-00522
06	07376-70628	02789-00628

2) Split flange type hoses and tubes

Nominal No.	Flange (hose end)	Sleeve head (tube end)	Split flange
04	07379-00400	07378-10400	07371-30400
05	07379-00500	07378-10500	07371-30500

3) If the part is not under hydraulic pressure, the following corks can be used.

Nominal No.	Part Number	Dimensions (mm)		
		D	d	L
06	07049-00608	6	5	8
08	07049-00811	8	6.5	11
10	07049-01012	10	8.5	12
12	07049-01215	12	10	15
14	07049-01418	14	11.5	18
16	07049-01620	16	13.5	20
18	07049-01822	18	15	22
20	07049-02025	20	17	25
22	07049-02228	22	18.5	28
24	07049-02430	24	20	30
27	07049-02734	22.5	22.5	34



2. Precautions when carrying out installation work

- Tighten all bolts and nuts (sleeve nuts) to the specified (KES) torque.
 - Install the hoses without twisting or interference and fix them with intermediate clamps, if there are any.
 - Replace all gaskets, O-rings, cotter pins, and lock plates with new parts.
 - Bend the cotter pins and lock plates securely.
 - When coating with adhesive, clean the part and remove all oil and grease, then coat the threaded portion with 2 - 3 drops of adhesive.
 - When coating with gasket sealant, clean the surface and remove all oil and grease, check that there is no dirt or damage, then coat uniformly with gasket sealant.
 - Clean all parts, and correct any damage, dents, burrs, or rust.
 - Coat rotating parts and sliding parts with engine oil.
 - When press fitting parts, coat the surface with anti-friction compound (LM-P).
 - After fitting snap rings, check that the snap ring is fitted securely in the ring groove.
 - When connecting wiring connectors, clean the connector to remove all oil, dirt, or water, then connect securely.
 - When using eyebolts, check that there is no deformation or deterioration, screw them in fully, and align the direction of the hook.
 - When tightening split flanges, tighten uniformly in turn to prevent excessive tightening on one side.
- ★ When operating the hydraulic cylinders for the first time after reassembling cylinders, pumps and other hydraulic equipment removed for repair, always bleed the air as follows:
- 1) Start the engine and run at low idle.
 - 2) Operate the work equipment control lever to operate the hydraulic cylinder 4 - 5 times, stopping the cylinder 100 mm from the end of its stroke.
 - 3) Next, operate the hydraulic cylinder 3 - 4 times to the end of its stroke.
- ★ When using the lift truck for the first time after repair or long storage, follow the same procedure.

3. Precautions when completing operation

- 1) Refilling with coolant, oil and grease
 - If the coolant has been drained, tighten the drain valve, and add coolant to the specified level. Run the engine to circulate the coolant through the system. Then check the coolant level again.
 - If the hydraulic equipment has been removed and installed again, add engine oil to the specified level. Run the engine to circulate the oil through the system. Then check the oil level again.
 - If the hydraulic equipment has been removed, always bleed the air from the system after reassembling the parts, referring to Testing and adjusting.
 - Add the specified amount of grease (molybdenum disulfide grease) to the work equipment parts.
- 2) Checking cylinder head and manifolds for looseness

Check the cylinder head and intake and exhaust manifold for looseness.

If any part is loosened, retighten it.

 - For the tightening torque, see "Disassembly and assembly".
- 3) Checking engine piping for damage and looseness

Intake and exhaust system

Check the piping for damage, the mounting bolts and nuts for looseness, and the joints for air suction and exhaust gas leakage.

If any part is loosened or damaged, retighten or repair it.

Cooling system

Check the piping for damage, the mounting bolts and nuts for looseness, and the joints for coolant leakage.

If any part is loosened or damaged, retighten or repair it.

Fuel system

Check the piping for damage, the mounting bolts and nuts for looseness, and the joints for fuel leakage.

If any part is loosened or damaged, retighten or repair it.

- 4) Checking muffler and exhaust pipe for damage and looseness
 - 1] Visually check the muffler, exhaust pipe and their mounting parts for a crack and damage.
If any part is damaged, replace it.
 - 2] Check the mounting bolts and nuts of the muffler, exhaust pipe and their mounting parts for looseness.
If any part is loosened, retighten it.
- 5) Checking muffler function
Check the muffler for abnormal sound and sound different from that of a new muffler.
If any abnormal sound is heard, repair the muffler, referring to “Troubleshooting” and “Disassembly and assembly”.

Standard tightening torque table

1. Table of tightening torques for bolts and nuts

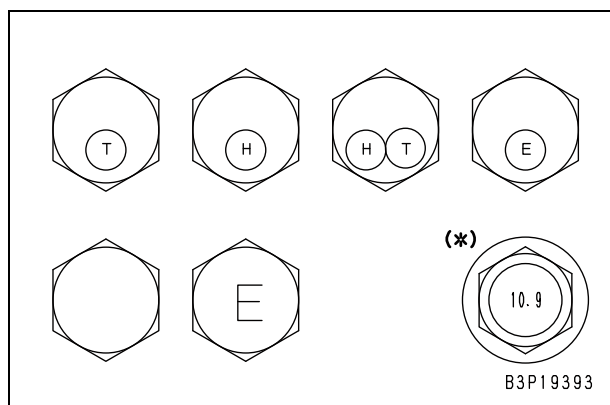
- ★ Unless there are special instructions, tighten metric nuts and bolts to the torque below.
- ★ The following table corresponds to the bolts in Fig. A.

Bolt Thread diameter	Width across flats	Tightening torque	
		Nm	kgfm
6	10	11.8 - 14.7	1.2 - 1.5
8	13	27 - 34	2.8 - 3.5
10	17	59 - 74	6.0 - 7.5
12	19	98 - 123	10.0 - 12.5
14	22	157 - 196	16 - 20
16	24	245 - 309	25 - 31.5
18	27	343 - 427	35 - 43.5
20	30	490 - 608	50 - 62
22	32	662 - 829	67.5 - 84.5
24	36	824 - 1,030	84 - 105
27	41	1,180 - 1,470	120 - 150
30	46	1,520 - 1,910	155 - 195
33	50	1,960 - 2,450	200 - 250
36	55	2,450 - 3,040	250 - 310
39	60	2,890 - 3,630	295 - 370

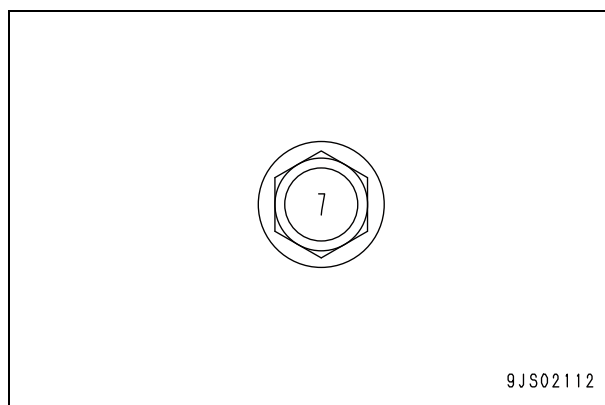
- ★ The following table corresponds to the bolts in Fig. B.

Bolt Thread diameter	Width across flats	Tightening torque	
		Nm	kgfm
6	10	5.9 - 9.8	0.6 - 1.0
8	12	13.7 - 23.5	1.4 - 2.4
10	14	34.3 - 46.1	3.5 - 4.7
12	27	74.5 - 90.2	7.6 - 9.2

★ Fig. A



★ Fig. B



Remarks: The widths across flats against the thread diameters of flanged bolts (marks with “*”) in Fig. A are the ones indicated in the table for bolts shown in Fig. B.
(Values of tightening torques shown in the table for Fig. A are applied.)

2. Table of tightening torques for split flange bolts

★ Unless there are special instructions, tighten split flange bolts to the torque below.

Thread diameter of bolt	Width across flats	Tightening torque	
mm	mm	Nm	kgfm
10	14	59 - 74	6.0 - 7.5
12	17	98 - 123	10.0 - 12.5
16	22	235 - 285	23.5 - 29.5

3. Table of tightening torques for O-ring boss piping joints

★ Unless there are special instructions, tighten O-ring boss piping joints to the torque below.

Nominal No.	Thread diameter of bolt	Width across flats	Tightening torque Nm {kgfm}	
	mm	mm	Range	Target
02	14	Varies depending on type of connector	35 - 63{3.5 - 6.5}	44 {4.5}
03, 04	20		84 - 132{8.5 - 13.5}	103 {10.5}
05, 06	24		128 - 186{13.0 - 19.0}	157 {16.0}
10, 12	33		363 - 480{37.0 - 49.0}	422 {43.0}
14	42		746 - 1,010{76.0 - 103}	883 {90.0}

4. Table of tightening torques for O-ring boss plugs

★ Unless there are special instructions, tighten O-ring boss plugs to the torque below.

Nominal No.	Thread diameter of bolt	Width across flats	Tightening torque Nm {kgfm}	
	mm	mm	Range	Target
08	8	14	5.88 - 8.82 {0.6 - 0.9}	7.35 {0.75}
10	10	17	9.8 - 12.74 {1.0 - 1.3}	11.27 {1.15}
12	12	19	14.7 - 19.6 {1.5 - 2.0}	17.64 {1.8}
14	14	22	19.6 - 24.5 {2.0 - 2.5}	22.54 {2.3}
16	16	24	24.5 - 34.3 {2.5 - 3.5}	29.4 {3.0}
18	18	27	34.3 - 44.1 {3.5 - 4.5}	39.2 {4.0}
20	20	30	44.1 - 53.9 {4.5 - 5.5}	49.0 {5.0}
24	24	32	58.8 - 78.4 {6.0 - 8.0}	68.6 {7.0}
30	30	32	93.1 - 122.5 {9.5 - 12.5}	107.8 {11.0}
33	33	—	107.8 - 147.0 {11.0 - 15.0}	127.4 {13.0}
36	36	36	127.4 - 176.4 {13.0 - 18.0}	151.9 {15.5}
42	42	—	181.3 - 240.1 {18.5 - 24.5}	210.7 {21.5}
52	52	—	274.4 - 367.5 {28.0 - 37.5}	323.4 {33.0}

5. Table of tightening torques for hoses (taper seal type and face seal type)

★ Unless there are special instructions, tighten the hoses (taper seal type and face seal type) to the torque below.

★ Apply the following torque when the threads are coated (wet) with engine oil.

Nominal No. of hose	Width across flats (mm)	Tightening torque Nm {kgfm}		Taper seal Thread size (mm)	Face seal	
		Range	Target		Nominal No. - Number of threads, type of thread	Thread diameter (mm) (Reference)
02	19	34 - 54 {3.5 - 5.5}	44 {4.5}	—	9/16-18UNF	14.3
		34 - 63 {3.5 - 6.5}	44 {4.5}	14	—	—
03	22	54 - 93 {5.5 - 9.5}	74 {7.5}	—	11/16-16UN	17.5
	24	59 - 98 {6.0 - 10.0}	78 {8.0}	18	—	—
04	27	84 - 132 {8.5 - 13.5}	103 {10.5}	22	13/16-16UN	20.6
05	32	128 - 186 {13.0 - 19.0}	157 {16.0}	24	1-14UNS	25.4
06	36	177 - 245 {18.0 - 25.0}	216 {22.0}	30	1-3/16-12UN	30.2
(10)	41	177 - 245 {18.0 - 25.0}	216 {22.0}	33	—	—
(12)	46	197 - 294 {20.0 - 30.0}	245 {25.0}	36	—	—
(14)	55	246 - 343 {25.0 - 35.0}	294 {30.0}	42	—	—

6. Table of tightening torques for face seal joint

- ★ Tighten the face joint seals (sleeve nut type) of steel pipes for plated low-pressure piping in engines etc. to the torque below.
- ★ Apply the following torque when the threads are coated (wet) with engine oil.

Suitable pipe outside diameter (mm)	Width across flats (mm)	Tightening torque Nm {kgfm}		Face seal	
		Range	Target	Nominal No. - Number of threads, type of thread	Thread diameter (mm) (Reference)
8	19	14 - 16 {1.4 - 1.6}	15 {1.5}	9/16-18UN	14.3
10	22	24 - 27 {2.4 - 2.7}	25.5 {2.6}	11/16-16UN	17.5
12	24 (27)	43 - 47 {4.4 - 4.8}	45 {4.6}	13/16-16UN	20.6
15 (16)	30 (32)	60 - 68 {6.1 - 6.8}	64 {6.5}	1-14UN	25.4
22 (20)	36	90 - 95 {9.2 - 9.7}	92.5 {9.4}	1-3/16-12UN	30.2

7. Table of tightening torques for 107 engine series (mounted on EX50 Series) (Bolts and nuts)

- ★ Unless there are special instructions, tighten the metric bolts and nuts of the 107 engine series to the torque below.
- ★ For tightening torques for 95 engine series, see “Standard tightening torque table”.

Thread size	Tightening torque	
	Bolts and nuts	
mm	Nm	kgfm
6	10 ± 2	1.02 ± 0.20
8	24 ± 4	2.45 ± 0.41
10	43 ± 6	4.38 ± 0.61
12	77 ± 12	7.85 ± 1.22
14	—	—

8. Table of tightening torques for 107 engine series (mounted on EX50 Series) (Eye joints)

- ★ Unless there are special instructions, tighten the metric eye joints of the 107 engine series to the torque below.
- ★ For tightening torques for 95 engine series, see “Standard tightening torque table”.

Thread size	Tightening torque	
	Nm	
mm	Nm	kgfm
6	8 ± 2	0.81 ± 0.20
8	10 ± 2	1.02 ± 0.20
10	12 ± 2	1.22 ± 0.20
12	24 ± 4	2.45 ± 0.41
14	36 ± 5	3.67 ± 0.51

9. Table of tightening torques for 107 engine series (mounted on EX50 Series) (Taper screws)

- ★ Unless there are special instructions, tighten the taper screws (unit: inch) of the 107 engine series to the torque below.
- ★ For tightening torques for 95 engine series, see “Standard tightening torque table”.

Material	Tightening torque			
	Cast iron or steel		Aluminium	
	Nm	kgfm	Nm	kgfm
Thread size (inch)				
1/16	15 ± 2	1.53 ± 0.20	5 ± 1	0.51 ± 0.10
1/8	20 ± 2	2.04 ± 0.20	15 ± 2	1.53 ± 0.20
1/4	25 ± 3	2.55 ± 0.20	20 ± 2	2.04 ± 0.20
3/8	35 ± 4	3.57 ± 0.41	25 ± 3	2.55 ± 0.20
1/2	55 ± 6	5.61 ± 0.61	35 ± 4	3.57 ± 0.41
3/4	75 ± 8	7.65 ± 0.82	45 ± 5	4.59 ± 0.51

Conversion table

Method of using the conversion table

The conversion table in this section is provided to enable simple conversion of figures. For details of the method of using the conversion table, see the example given below.

Example: Method of using the conversion table to convert from millimeters to inches

1. Convert 55 mm into inches.

- 1) Locate the number 50 in the vertical column at the left side, take this as (A), and then draw a horizontal line from (A).
- 2) Locate the number 5 in the row across the top, take this as (B), then draw a perpendicular line down from (B).
- 3) Take the point where the 2 lines cross as (C). This point (C) gives the value when converting from millimeters to inches. Therefore, 55 mm = 2.165 inches.

2. Convert 550 mm into inches.

- 1) The number 550 does not appear in the table, so divide it by 10 (move the decimal point one place to the left) to convert it to 55 mm.
- 2) Carry out the same procedure as above to convert 55 mm to 2.165 inches.
- 3) The original value (550 mm) was divided by 10, so multiply 2.165 inches by 10 (move the decimal point one place to the right) to return to the original value. This gives 550 mm = 21.65 inches.

Millimeters to inches

(B)

1 mm = 0.03937 in

	0	1	2	3	4	5	6	7	8	9
0	0	0.039	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354
10	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748
20	0.787	0.827	0.866	0.906	0.945	0.984	1.024	1.063	1.102	1.142
30	1.181	1.220	1.260	1.299	1.339	1.378	1.417	1.457	1.496	1.536
40	1.575	1.614	1.654	1.693	1.732	1.772	1.811	1.850	1.890	1.929
(A) 50	1.969	2.008	2.047	2.087	2.126	2.165	2.205	2.244	2.283	2.323
60	2.362	2.402	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.717
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.032	3.071	3.110
80	3.150	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.465	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

Millimeters to inches

1 mm = 0.03937 in

	0	1	2	3	4	5	6	7	8	9
0	0	0.039	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354
10	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748
20	0.787	0.827	0.866	0.906	0.945	0.984	1.024	1.063	1.102	1.142
30	1.181	1.220	1.260	1.299	1.339	1.378	1.417	1.457	1.496	1.536
40	1.575	1.614	1.654	1.693	1.732	1.772	1.811	1.850	1.890	1.929
50	1.969	2.008	2.047	2.087	2.126	2.165	2.205	2.244	2.283	2.323
60	2.362	2.402	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.717
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.032	3.071	3.110
80	3.150	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.465	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

Kilogram to pound

1 kg = 2.2046 lb

	0	1	2	3	4	5	6	7	8	9
0	0	2.20	4.41	6.61	8.82	11.02	13.23	15.43	17.64	19.84
10	22.05	24.25	26.46	28.66	30.86	33.07	35.27	37.48	39.68	41.89
20	44.09	46.30	48.50	50.71	51.91	55.12	57.32	59.53	61.73	63.93
30	66.14	68.34	70.55	72.75	74.96	77.16	79.37	81.57	83.78	85.98
40	88.18	90.39	92.59	94.80	97.00	99.21	101.41	103.62	105.82	108.03
50	110.23	112.44	114.64	116.85	119.05	121.25	123.46	125.66	127.87	130.07
60	132.28	134.48	136.69	138.89	141.10	143.30	145.51	147.71	149.91	152.12
70	154.32	156.53	158.73	160.94	163.14	165.35	167.55	169.76	171.96	174.17
80	176.37	178.57	180.78	182.98	185.19	187.39	189.60	191.80	194.01	196.21
90	198.42	200.62	202.83	205.03	207.24	209.44	211.64	213.85	216.05	218.26

Liters to U.S. Gallons

1 ℓ = 0.2642 U.S. Gal

	0	1	2	3	4	5	6	7	8	9
0	0	0.264	0.528	0.793	1.057	1.321	1.585	1.849	2.113	2.378
10	2.642	2.906	3.170	3.434	3.698	3.963	4.227	4.491	4.755	5.019
20	5.283	5.548	5.812	6.076	6.340	6.604	6.869	7.133	7.397	7.661
30	7.925	8.189	8.454	8.718	8.982	9.246	9.510	9.774	10.039	10.303
40	10.567	10.831	11.095	11.359	11.624	11.888	12.152	12.416	12.680	12.944
50	13.209	13.473	13.737	14.001	14.265	14.529	14.795	15.058	15.322	15.586
60	15.850	16.115	16.379	16.643	16.907	17.171	17.435	17.700	17.964	18.228
70	18.492	18.756	19.020	19.285	19.549	19.813	20.077	20.341	20.605	20.870
80	21.134	21.398	21.662	21.926	22.190	22.455	22.719	22.983	23.247	23.511
90	23.775	24.040	24.304	24.568	24.832	25.096	25.361	25.625	25.889	26.153

Liters to U.K. Gallons

1 ℓ = 0.21997 U.K. Gal

	0	1	2	3	4	5	6	7	8	9
0	0	0.220	0.440	0.660	0.880	1.100	1.320	1.540	1.760	1.980
10	2.200	2.420	2.640	2.860	3.080	3.300	3.520	3.740	3.950	4.179
20	4.399	4.619	4.839	5.059	5.279	5.499	5.719	5.939	6.159	6.379
30	6.599	6.819	7.039	7.259	7.479	7.699	7.919	8.139	8.359	8.579
40	8.799	9.019	9.239	9.459	9.679	9.899	10.119	10.339	10.559	10.778
50	10.998	11.281	11.438	11.658	11.878	12.098	12.318	12.528	12.758	12.978
60	13.198	13.418	13.638	13.858	14.078	14.298	14.518	14.738	14.958	15.178
70	15.398	15.618	15.838	16.058	16.278	16.498	16.718	16.938	17.158	17.378
80	17.598	17.818	18.037	18.257	18.477	18.697	18.917	19.137	19.357	19.577
90	19.797	20.017	20.237	20.457	20.677	20.897	21.117	21.337	21.557	21.777

kgm to ft.lb

1 kgm = 7.233 ft.lb

	0	1	2	3	4	5	6	7	8	9
0	0	7.2	14.5	21.7	28.9	36.2	43.4	50.6	57.9	65.1
10	72.3	79.6	86.8	94.0	101.3	108.5	115.7	123.0	130.2	137.4
20	144.7	151.9	159.1	166.4	173.6	180.8	188.1	195.3	202.5	209.8
30	217.0	224.2	231.5	238.7	245.9	253.2	260.4	267.6	274.9	282.1
40	289.3	296.6	303.8	311.0	318.3	325.5	332.7	340.0	347.2	354.4
50	361.7	368.9	376.1	383.4	390.6	397.8	405.1	412.3	419.5	426.8
60	434.0	441.2	448.5	455.7	462.9	470.2	477.4	484.6	491.8	499.1
70	506.3	513.5	520.8	528.0	535.2	542.5	549.7	556.9	564.2	571.4
80	578.6	585.9	593.1	600.3	607.6	614.8	622.0	629.3	636.5	643.7
90	651.0	658.2	665.4	672.7	679.9	687.1	694.4	701.6	708.8	716.1
100	723.3	730.5	737.8	745.0	752.2	759.5	766.7	773.9	781.2	788.4
110	795.6	802.9	810.1	817.3	824.6	831.8	839.0	846.3	853.5	860.7
120	868.0	875.2	882.4	889.7	896.9	904.1	911.4	918.6	925.8	933.1
130	940.3	947.5	954.8	962.0	969.2	976.5	983.7	990.9	998.2	1005.4
140	1012.6	1019.9	1027.1	1034.3	1041.5	1048.8	1056.0	1063.2	1070.5	1077.7
150	1084.9	1092.2	1099.4	1106.6	1113.9	1121.1	1128.3	1135.6	1142.8	1150.0
160	1157.3	1164.5	1171.7	1179.0	1186.2	1193.4	1200.7	1207.9	1215.1	1222.4
170	1129.6	1236.8	1244.1	1251.3	1258.5	1265.8	1273.0	1280.1	1287.5	1294.7
180	1301.9	1309.2	1316.4	1323.6	1330.9	1338.1	1345.3	1352.6	1359.8	1367.0
190	1374.3	1381.5	1388.7	1396.0	1403.2	1410.4	1417.7	1424.9	1432.1	1439.4

kg/cm² to lb/in²

$$1 \text{ kg/cm}^2 = 14.2233 \text{ lb/in}^2$$

	0	1	2	3	4	5	6	7	8	9
0	0	14.2	28.4	42.7	56.9	71.1	85.3	99.6	113.8	128.0
10	142.2	156.5	170.7	184.9	199.1	213.4	227.6	241.8	256.0	270.2
20	284.5	298.7	312.9	327.1	341.4	355.6	369.8	384.0	398.3	412.5
30	426.7	440.9	455.1	469.4	483.6	497.8	512.0	526.3	540.5	554.7
40	568.9	583.2	597.4	611.6	625.8	640.1	654.3	668.5	682.7	696.9
50	711.2	725.4	739.6	753.8	768.1	782.3	796.5	810.7	825.0	839.2
60	853.4	867.6	881.8	896.1	910.3	924.5	938.7	953.0	967.2	981.4
70	995.6	1,010	1,024	1,038	1,053	1,067	1,081	1,095	1,109	1,124
80	1,138	1,152	1,166	1,181	1,195	1,209	1,223	1,237	1,252	1,266
90	1,280	1,294	1,309	1,323	1,337	1,351	1,365	1,380	1,394	1,408
100	1,422	1,437	1,451	1,465	1,479	1,493	1,508	1,522	1,536	1,550
110	1,565	1,579	1,593	1,607	1,621	1,636	1,650	1,664	1,678	1,693
120	1,707	1,721	1,735	1,749	1,764	1,778	1,792	1,806	1,821	1,835
130	1,849	1,863	1,877	1,892	1,906	1,920	1,934	1,949	1,963	1,977
140	1,991	2,005	2,020	2,034	2,048	2,062	2,077	2,091	2,105	2,119
150	2,134	2,148	2,162	2,176	2,190	2,205	2,219	2,233	2,247	2,262
160	2,276	2,290	2,304	2,318	2,333	2,347	2,361	2,375	2,389	2,404
170	2,418	2,432	2,446	2,460	2,475	2,489	2,503	2,518	2,532	2,546
180	2,560	2,574	2,589	2,603	2,617	2,631	2,646	2,660	2,674	2,688
190	2,702	2,717	2,731	2,745	2,759	2,773	2,788	2,802	2,816	2,830
200	2,845	2,859	2,873	2,887	2,901	2,916	2,930	2,944	2,958	2,973
210	2,987	3,001	3,015	3,030	3,044	3,058	3,072	3,086	3,101	3,115
220	3,129	3,143	3,158	3,172	3,186	3,200	3,214	3,229	3,243	3,257
230	3,271	3,286	3,300	3,314	3,328	3,343	3,357	3,371	3,385	3,399
240	3,414	3,428	3,442	3,456	3,470	3,485	3,499	3,513	3,527	3,542

Temperature

Fahrenheit-Centigrade conversion: A simple way to convert a Fahrenheit temperature reading into a Centigrade temperature reading or vice versa is to enter the accompanying table in the center (boldface column) of figures. These figures refer to the temperature in either Fahrenheit or Centigrade degrees.

When convert from Fahrenheit to Centigrade degrees, consider the center column to be a table of Fahrenheit temperatures and read the corresponding Centigrade temperature in the column at the left.

When convert from Centigrade to Fahrenheit degrees, consider the center column to be a table of Centigrade values, and read the corresponding Fahrenheit temperature on the right.

$$1^{\circ}\text{C} = 33.8^{\circ}\text{F}$$

$^{\circ}\text{C}$		$^{\circ}\text{F}$	$^{\circ}\text{C}$		$^{\circ}\text{F}$	$^{\circ}\text{C}$		$^{\circ}\text{F}$	$^{\circ}\text{C}$		$^{\circ}\text{F}$
-40.4	-40	-40.0	-11.7	11	51.8	7.8	46	114.8	27.2	81	177.8
-37.2	-35	-31.0	-11.1	12	53.6	8.3	47	116.6	27.8	82	179.6
-34.4	-30	-22.0	-10.6	13	55.4	8.9	48	118.4	28.3	83	181.4
-31.7	-25	-13.0	-10.0	14	57.2	9.4	49	120.2	28.9	84	183.2
-28.9	-20	-4.0	-9.4	15	59.0	10.0	50	122.0	29.4	85	185.0
-28.3	-19	-2.2	-8.9	16	60.8	10.6	51	123.8	30.0	86	186.8
-27.8	-18	-0.4	-8.3	17	62.6	11.1	52	125.6	30.6	87	188.6
-27.2	-17	1.4	-7.8	18	64.4	11.7	53	127.4	31.1	88	190.4
-26.7	-16	3.2	-7.2	19	66.2	12.2	54	129.2	31.7	89	192.2
-26.1	-15	5.0	-6.7	20	68.0	12.8	55	131.0	32.2	90	194.0
-25.6	-14	6.8	-6.1	21	69.8	13.3	56	132.8	32.8	91	195.8
-25.0	-13	8.6	-5.6	22	71.6	13.9	57	134.6	33.3	92	197.6
-24.4	-12	10.4	-5.0	23	73.4	14.4	58	136.4	33.9	93	199.4
-23.9	-11	12.2	-4.4	24	75.2	15.0	59	138.2	34.4	94	201.2
-23.3	-10	14.0	-3.9	25	77.0	15.6	60	140.0	35.0	95	203.0
-22.8	-9	15.8	-3.3	26	78.8	16.1	61	141.8	35.6	96	204.8
-22.2	-8	17.6	-2.8	27	80.6	16.7	62	143.6	36.1	97	206.6
-21.7	-7	19.4	-2.2	28	82.4	17.2	63	145.4	36.7	98	208.4
-21.1	-6	21.2	-1.7	29	84.2	17.8	64	147.2	37.2	99	210.2
-20.6	-5	23.0	-1.1	30	86.0	18.3	65	149.0	37.8	100	212.0
-20.0	-4	24.8	-0.6	31	87.8	18.9	66	150.8	40.6	105	221.0
-19.4	-3	26.6	0	32	89.6	19.4	67	152.6	43.3	110	230.0
-18.9	-2	28.4	0.6	33	91.4	20.0	68	154.4	46.1	115	239.0
-18.3	-1	30.2	1.1	34	93.2	20.6	69	156.2	48.9	120	248.0
-17.8	0	32.0	1.7	35	95.0	21.1	70	158.0	51.7	125	257.0
-17.2	1	33.8	2.2	36	96.8	21.7	71	159.8	54.4	130	266.0
-16.7	2	35.6	2.8	37	98.6	22.2	72	161.6	57.2	135	275.0
-16.1	3	37.4	3.3	38	100.4	22.8	73	163.4	60.0	140	284.0
-15.6	4	39.2	3.9	39	102.2	23.3	74	165.2	62.7	145	293.0
-15.0	5	41.0	4.4	40	104.0	23.9	75	167.0	65.6	150	302.0
-14.4	6	42.8	5.0	41	105.8	24.4	76	168.8	68.3	155	311.0
-13.9	7	44.6	5.6	42	107.6	25.0	77	170.6	71.1	160	320.0
-13.3	8	46.4	6.1	43	109.4	25.6	78	172.4	73.9	165	329.0
-12.8	9	48.2	6.7	44	111.2	26.1	79	174.2	76.7	170	338.0
-12.2	10	50.0	7.2	45	113.0	26.7	80	176.0	79.4	175	347.0